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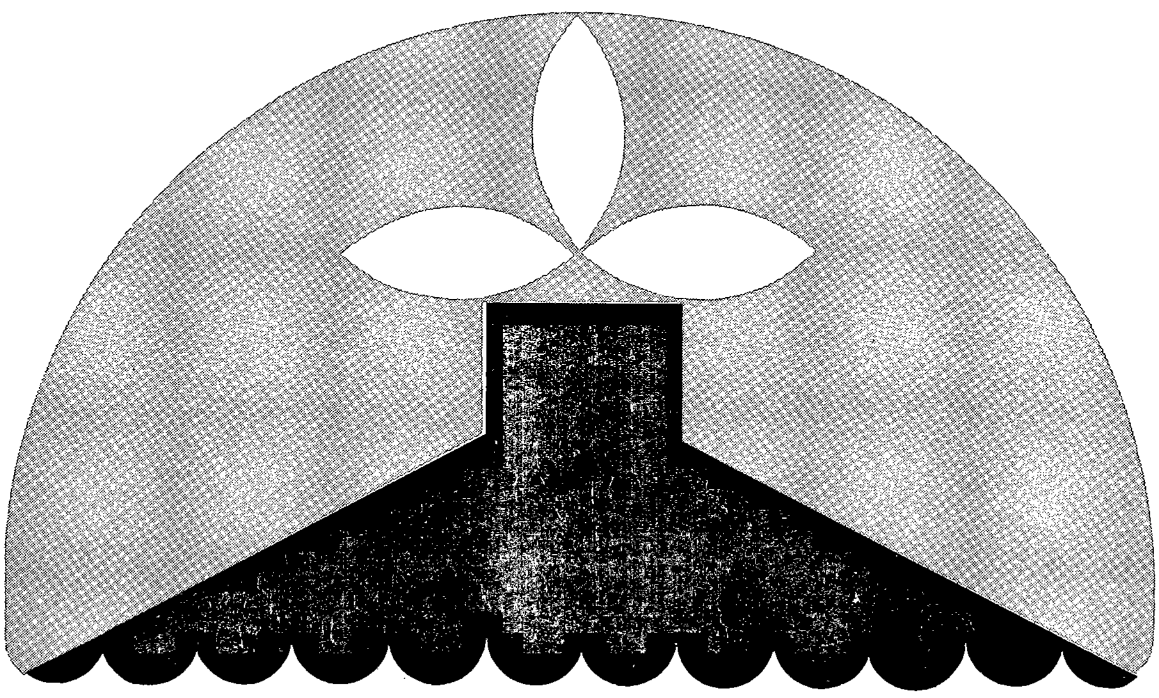

Seventh Annual Hawaii Fertilizer Conference
PROCEEDINGS

Seventh Annual Hawaii Fertilizer Conference
Hilton Hawaiian Village
Coral Ballroom
April 26, 1974

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WHERE HAS ALL THAT FERTILIZER GONE?

Edwin M. Wheeler
The Fertilizer Institute

There was a song in the ancient times (mid-1950) that had a line in it that has described so many things that I have never forgotten it. It was "for he's real gone" and it was always sung by a wailing female vocalist. Today, however, you are about to hear that line by a near-fifty, fat, male vocalist. The fertilizer shortage is real, and it's long gone!

Before we take a look at the current and, more germane to you, the future outlook of fertilizer supplies, I want to cover a matter of grave concern to me. Simply, it is the credibility or believability of the fertilizer industry in the current situation. My personal and professional credentials are on the line. Many of you couldn't care less about my personal situation, but I can assure you that, in your role as representatives or participants in an industry, you too get hit with a wildly flung tar brush if it is swung. So -- we can all be badly hurt as a group if this should come to pass. And well it might.

Consider, if you will, the wild accusations being made by certain members of the Congress aimed at the oil industry. While any industry with the size and the investment of the oil companies is not perfect--not Simon pure--it is not all bad either. The number of vehicles on our highways rose from 23 to 25 million at the end of World War II to over 90 million today. Farm uses alone are staggering. The U.S. uses annually 35 percent of all the energy consumed by the entire world. Yet, only in 1974 has there ever been a pinch. Retail gasoline in the U.S. is still the cheapest obtainable in the developed nations. A tremendous array of petrochemicals in staggering tonnages has been made available. Yet, only in 1974 has there been a shortage. Repeatedly the oil industry cautioned that over-restrictive environmental controls were preventing refinery expansion, offshore drilling, and so on. The area hurt the worst now has always howled the loudest--that is, the East Coast. From Maine, which just turned down another refinery site, to Delaware, which enacted a state law forbidding refineries, the politicos are screaming about "big oil."

Consistently, the oil industry warned of the situation: yet, where were the instant problem solvers then? Anyone literate could tell the storm was gathering. A declining amount of U.S. drilling, no expansion of refinery operations, and on and on--even the village idiot could tell what was going to happen. What did the now so critical Congress do then? NOTHING. As is obvious, it was not our politicians who brought the issue to the fore, it was the Arab embargo. You may be able to explain it to me, and I urge you to do so, but how in the world did the oil companies trigger off the Egyptian-Syrian attack on Israel? How could the oil companies be saddled with the blame for the Mid-East embargo? Not one scintilla of evidence has come forth on these two points. But, in a vintage year, when all 435 members of the House and 35 members of the Senate are at bat, you can be sure that not one of them--not one--will come home and say to you, "I goofed. I should have seen this coming and acted accordingly on your behalf."

Why the detour into oil? We of the fertilizer industry are in the twin boat to the oil corporations' good ship, Titanic.

From the beginning of 1968 on, our industry, due to excess capacity, wild price cutting, unbelievable credit practices, and so on, and so on, has dropped into a sea of red ink. 1969 was the worst year. 1970 was bad, but that year the loss was only in the $45 to $50 million range, compared to the previous loss of $170 million. Beginning in 1971 it looked as though Armageddon had passed until Congress enacted the Economic Control Act. The freeze on price and profits was a disaster. We, like all industries, were tied to the previous 3 years. By early December 1971, The Institute asked for decontrol on the basis that:

1. Fertilizer prices had been steadily declining.
2. We had no profits.
3. Price and profits of our industry had in no way contributed to the inflationary spiral.
4. There were many signs that our exports were beginning to surge.
5. New capacity would soon be needed.
6. No profits meant no new production.

No one, no one in the Administration, in Congress, or at the state level even bothered to yawn. Our predictions came true--yet, until the harvest of the forecasts, no one gave a hoot. Do you not see the parallel between the petroleum and fertilizer situations? Ample warning of the storm was given--ample ignoring of the same was equal. No one gave a damn about either forecast. Now all are seeking a scapegoat.

The proposed embargo on U.S. fertilizer is the knee-jerk reaction I had anticipated. Many of our lawmakers have once again come up with an instant solution to a problem with many real (not imagined) facets. It would be a disaster if the embargo were to become law. The U.S. imports 65 percent of its potash--nearly all of which is Canadian. We import substantial tonnages of nitrogen. Every nation in the top ten, save one, India, could severly retaliate by cutting off coffee, iron ore, copper--the list is endless. Turning off the spigot of bounty by our country would bring instant retaliation.

Completely apart-- are we so self-centered, so crass, so uncharitable that we cannot spare the 10 to 15 percent of our production to help the emerging nations? I hope not, for if your Congress adopts this approach, cannot one then ask, "What has happened to our country when money means more than life itself?"

So, finally, we come to the question, "Where Has All That Fertilizer Gone?" Quite simply, it has gone off to the war against starvation. This is a new war, for you will recall the earlier war was against a lesser foe, hunger. Grain reserves have dropped to the lowest levels since 1945. Every nation is closely husbanding its supplies; but of greater impact and importance, every government is encouraging maximum production. For the U.S., this means virtually no restrictions on acreage, a wide latitude on crops to be grown, and a guaranteed floor on prices. This is nearly without precedent. With wheat prices very high last fall, the "gold rush" was on for fertilizer on a demand basis heretofore unknown. Inventories dropped to a very low level, and they have never recovered.

What lies ahead? Assuming that grains have once again firmed or bottomed out, we would anticipate nitrogen will be hand to mouth for some time to come. Until we can get additional gas supplies, domestic capacity is not going to be able to expand. Our June 30, 1974 forecast is a shortage of 3 million tons of nitrogen and about 1.5 plus million tons of phosphates. Potash is very difficult to estimate because of the shortage of hopper cars. Large tonnages of potash have been shipped from Saskatchewan, but the amount will not be enough for domestic use.

Relief is on the way in phosphates. If announced new capacity is on line when we think it will be, 1976 is the year for renewed competitive struggles. Hopefully, and guardedly, it will not be the 1968 bloodbath repeated.

Continued world growth in population is with us. For many complex reasons, we do not seem about to master this, the most vexatious problem of our time. Failing to resolve the population surge would bring us back to the prophecy of the early 1960s--the Tom Ware syndrome, as it were. I only hope that we consider several major differences before euphoria sinks us again.

First, as cruel as it sounds, some permanent financing must be established for grain and fertilizer shipments to the emerging nations. It might be possible for the oil-rich nations to assist on one or both of these commodities. New fertilizer production based on U.S. programs, such as the current AID concept, is as permanent as quicksand.

Second, some reasonable system in Canada and the United States will have to be developed on an orderly expansion of gas used in new nitrogen facilities. Short of this we could not only be guilty of the waste of a precious asset but of the crime of stupidity.

Third, in the long haul, we must have ever larger agricultural exports from the U.S. to pay for growing oil, ores, and raw material imports. Whether this would envision Export Boards similar to the Canadian Wheat Board, I do not know. This I do know, that all of agriculture must be alert to examine new ideas and new approache and must not condemn them out of hand. We would be foolish if we were not to recognize the body politic will insist on certain minimum U.S. levels of grain reserves. Equally, another wheat rush, such as occurred in 1973, probably would not be acceptable in the future. Our industry needs to give thought, therefore, to the participation in formulation of these new concepts. Parenthetically, our government ought to occasionally consult with us before announcing grandiose schemes.

And, finally, earlier in the speech I alluded to the word "credibility." I would like to read you the definition of credibility: "capable of being believed; worthy of belief; entitled to confidence; trustworthy." And how do we, as the fertilizer industry, achieve the objective of project "credibility"?

1. We need to inform all people about the total fertilizer supply situation.
2. Of greater importance, we need to price our products fairly with a justifiable fair return on our investment. Keep in mind that these are the same people you will be selling to for many years in various marketing situations
3. We need to inform our customers as to the actual commitments on delivery, as expediently as the information is available.
4. You need to establish a formal company policy on delivery, developed on criteria such as (a) past history of dealings, and (b) equal treatment for all regardless of size. Your company policy should be spelled out clearly for all to review at any time.

I would like to leave you with this thought: the future of the U.S. fertilizer industry is coupled with the American farmer. Only when the farmer prospers can those who serve him enjoy economic health.

LAND DISPOSAL OF SEWAGE EFFLUENT: MILILANI STUDY[1]

Paul C. Ekern
University of Hawaii

The current status of land disposal of wastewaters has been characterized thusly

> Land disposal, the practice of disposing of domestic and industrial wastewaters in the earth's soil mantle instead of its surface waters, has received a great deal of publicity over the past few years and has acquired many influential advocates who have promoted the age-old method to the point where it could become the only method of wastewater disposal legally permitted anywhere in the country. This shift of thinking from water disposal to land disposal has occurred despite the fact that many wastewater professionals have advised that land disposal is a very costly strategy and have warned that extensive use of land disposal systems will result in the devastation of vast areas of land, serious contamination of the air, accelerated depletion of power resources, and ultimately, more severe water pollution than that which exists today. (Egeland 1973).

Why then make the Mililani study? Mililani Town has a current population of 7000, with an output of 0.7 MGD (million gallons per day) of chlorinated effluent; the 1980 projected population is 70,000 with an output of 7 MGD. Currently, this effluent is discharged into a side branch of Kipapa Stream, thence into Waikele Stream, and finally into West Loch, Pearl Harbor. The effects upon the quality of these receiving waters are even now subject to EPA regulation. Even though Oahu Sugar Company transports water from the windward Koolaus via the Waiahole Ditch to irrigate sugarcane in central Oahu, the amount of water does not meet the irrigation needs for cane adjacent to Mililani. Thus, both the high-level water (250-foot water table) in the Schofield plateau, which is now used for the urban needs of Mililani, and the low-level water (26-foot table) will be pumped to meet the increased urban demands. The effects of land disposal on these groundwaters, in terms of quantity and quality, although not yet subject to stringent EPA regulation, are still of immediate concern in order to maintain the potable quality of these groundwaters. The Mililani Study on the effects of land disposal of sewage effluent began in 1972 and is a continuing project.

How is the study designed? Stream flow and water quality are measured above the confluence of Kipapa and Waikele streams in order to check the effect of the current land disposal practice. Minor amounts of the effluent have been used to water the grass at the sewage treatment plant and might one day be used to irrigate the golf course or parks. The amounts that would appear as deep percolate or be used in evapotranspiration by the grass are measured by lysimeters, and samples of the percolate are measured for the fate of the chemical and biologic components of the effluent. Other lysimeters are used to measure the same parameters when the soil is fallow (bare) and when sugarcane is grown with furrow irrigation. Since both the extra

[1]This study is being supported in part by funds provided by the Office of Water Resources, Research Project A-039, "Sediment Rating Curves"; the City and County of Honolulu, Division of Sewers, "Recycling of Water from Sewage by Irrigation"; and the Board of Water Supply, "Mililani Recycling Project"; HSPA; and Oahu Sugar Co.

water and the nutrients can change cane growth and sugar content, a replicated field study for cane sugar production under effluent, as opposed to Waiahole Ditch water, was initiated in February 1973, for harvest in November 1974.

What is the quality of the chlorinated effluent? Table 1 lists many constituents of effluent that are vital to plant growth and the potability of the receiving waters (Baier and Fryer 1973). Chlorination effectively controls bacteriologic contents, but an unknown health hazard persists in the viral remnants in the effluent (Bernarde 1973). The biochemical oxygen demand (BOD) indicates sufficient readily decomposable organic carbon to sustain microbial growth. The chloride level is low, and the total salt--indicated by an electrical conductivity of 500 micromhos/cm--is tolerated by cane (Syed and El-Swaify 1972). Most crops tolerate the 0.5 ppm of B, although some sensitive crops are damaged by 0.33 ppm B (Richards 1954). Heavy metals are present only in parts/billion and pesticides in parts/trillion. The Si level of 65 to 70 ppm is derived from the Schofield high-level diked water and makes an excellent tracer for the progress of the water, whether as percolate or surface flow (Davis 1969). The levels of the major nutrients of N-P-K as 20-10-10 ppm form a well-balanced fertilizer and the application of 100 inches of effluent would supply 452 lb/acre of N, 226 lb/acre of P (518 lb. P_2O_5), and 226 lb/acre of K (545 lb. K_2O). An evaporation rate of 0.2 inches/day (Ekern 1972) would require continuous irrigation of 200 acres/day to dispose of the 38.3 inches/day/acre, equivalent to 1 MGD, and dispose of 73 inches/year. Disposal by evaporation alone of the anticipated 7 MGD output would require continuous daily irrigation of 1400 acres.

What soil receives the effluent? Red oxisols of the Lahaina and Wahiawa series dominate the area and represent soils on which 90 percent of the irrigated sugarcane is grown. The water-release curves for the Molokai and Wahiawa soils demonstrate the extreme cases for these well-aggregated latosols (Sharma and Uehara 1968, I and II; Ekern 1966). Water movement through the profile is slow, and roots are confined to the immediate surface layers by the compact tillage pan (Trouse and Humbert 1961). The soil aggregates are quite stable and little subject to dispersion even by the Na in the effluent (El-Swaify 1969). Solute dispersion breakthrough curves are rapid for chloride, but lag greatly for K and P (Cagauan, et al. 1968). Diffusion of nitrate in the aggregate micropores can slow the removal of N in percolating waters (Balasubramanian, et al. 1973). The cation exchange capacities of the Wahiawa and Lahaina soils were 25 to 30 meq/100 g in the plow layers, but only 15 meq/100 g in the subsoils (Swindale and Uehara 1966). The sorption of virus by latosols is at best partial (Young and Burbank 1973). The water-extractable Si for these red soils was only 2 to 3.5 ppm, but it increased to 10 to 13 ppm where high-Si irrigation water had been used (Fox, et al. 1967).

What are the results for Kipapa Stream? Effluent discharge dominates the low flow (1 cfs) of Kipapa Stream and has induced a new semidiurnal regimen determined by the semidiurnal pattern of barometric air pressure (van Hylckama 1968) (Fig. 1). The 10 ppm NO_3-N and 60 ppm SiO_2 of this low flow indicate the persistance of the effluent in overland flow (Fig. 2). High flow dilutes the effluent with stream waters of 0.05 ppm No_3-N and 6 ppm Si. Kipapa Ditch of Oahu Sugar Company withdraws 5 to 6 cfs of the Kipapa Stream flow and, during the irrigation season, diverts a major part of the original stream. The N in the effluent is converted to nitrate and carried downstream.

What happens with land disposal under grass sod? Irrigation with 141.28 inches of chlorinated effluent containing 578 lb/acre of N on the sod lysimeter from January through December 1973 harvested 53.7 percent of the applied N in the grass, had an estimated 13.5 percent of the N in the roots, allowed only 2.7 percent of the N to percolate, but had an estimated 30.1 percent of the N unaccounted. Potassium in the effluent displaced Ca and Mg from the soil exchange, Na remained unchanged, P was almost completely retained, and Si was reduced to equilibrium levels of 15 ppm (Table 2) Rainfall of 21.04 inches plus irrigation of 154.36 inches produced 87.96 inches of percolate. Measured water use for the lysimeter was 78.30 inches, with the discrepancy of 87.44 - 78.30 = 9.14 inches represented by changes in soil water storage and differences in the rainfall catch between a standard 8-inch gage and a 4-foot lysimeter (Table 3) (Morgan and Lourance 1969).

What happens with land disposal on fallow soil? Irrigation with 16.58 inches of effluent that held 74.7 lb/acre of N on bare soil from November 1973 through January 1974 lost 95 lb/acre of No_3-N in 22.9 inches of percolate. The changes in the other elements were similar to those for sod, though Na played a more prominent part in displacement of Ca and Mg from the cation exchange (Table 2). Nitrogen mineralization from the soil contributed to the nitrate losses, hence more N was removed than was added to the profile. This parallels the pattern found for the initial stages under sugarcane (Ekern 1970) and under sod (Lau, et al. 1972).

What happens with land disposal under furrow irrigation of sugarcane? Irrigatio with 59.63 inches of effluent that held 251.9 lb/acre of N (76.9 lb. in effluent plus 175 lb. of N fertilizer) on a cane lysimeter from June through December 1973 lost 124.1 lb/acre of NO_3-N in 33.88 inches of percolate (Table 4). Irrigation with 45.50 inches of Waiahole Ditch water (with 250 lb/acre of N fertilizer) on a cane lysimeter for the same period lost 34 lb/acre of NO_3-N in 13.27 inches of percolate. Nitrate in the root zone recovered in ceramic cups under 0.5 bar suction during irrigation with ditch water fluctuated widely after each fertilization, but by December it was reduced to 1 ppm NO_3-N (Fig. 3). Nitrate in the root zone under effluent irrigation fluctuated less widely with the reduced applications of N fertilizer, but by December it was still 10 ppm of NO_3-N. Twenty rounds of irrigation were applied from February 1973 through March 1974. Metered application of irrigation of 78.09 inches plus 38.05 inches of rainfall gave 36.85 inches of percolate, or 79.29 inches of water used by the cane. The percolate percentage is 36.85/78.09, or 47 percent of the irrigation application. However, this percolate is primarily from the winter rains that flushed the soil, since only 18.01/73.65, or 24.5 percent, percolated from February through December 1973. Crop logs (Clements, 1972) have indicated little differences in growth and N status during the first year, despite N applications from 380 to 475 lb/acre. Crop yields will be assessed at harvest in November 1974 from the replicated experiment.(Table 5).

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Table 1. Composition of raw sewage and chlorinated effluent, Mililani Sewage Treatment Plant, 1971-1974

Constituent	Median raw sewage[a]	Effluent				
		Composite 10/71	Composite 6/73	Median sod irrig.[b]	Avg fallow irrig.[c]	Avg cane irrig.[d]
	ppm					
Dissolved solids	502		351	336		
Settleable solids		0.1	0.6			
Suspended solids	210		7	22		
Grease	43.7	18	21.6			
Biochemical oxygen demand	208	16	8			
Chemical oxygen demand		28	113			
Chloride	43	60	50	49.5	51.4	56
Sulfate	69	85	52	47.5	37.6	39
Boron	0.55	0.10	0.5			
Silica	67	44	60	62	72.9	69.5
Nitrate-nitrogen	0.1	4.5	0.206	0.4		
Kjeldahl-nitrogen	38.6	9.5	17.36	16.1		
Total nitrogen	38.7	14	17.57	16.5	19.95	20.87
Total phosphorus	16.5	17.9	15.4	7.1	12.04	12.4
Sodium	56	64	53	54	59.08	50.7
Potassium	11	5.8	10.5	9.9	9.48	9.8
Calcium	16	9	14.5	11	11.85	13.8
Conductivity, micromhos/cm	520		450-600	400	461	424
pH range		5.8-6.2	6.8-7.2			

[a]Raw sewage median of grab samples, daylight hours, January 1972-July 1973.

[b]Sod irrigation median of grab samples, July 1972-July 1973.

[c]Fallow irrigation average of samples, December 1973-January 1974.

[d]Cane irrigation average of samples, June 1973-December 1973.

Table 2. Lysimeter percolates: composition and relative concentration, Mililani, 1971-1973

Constituent	Sod[a]	Sod[b]	Fallow	Cane	Ratio of concentration: percolate/effluent Sod	Fallow	Cane
	ppm						
Chloride	50.7	52	46.3	98.86	1.05	0.937	2.0
Sulfate	67	75	33.8	12.97	1.58	0.71	0.273
Total nitrogen	0.02	0.02	18.35	15.9	0.012	0.95	0.975
Phosphorus	0.02	0.02	0.034	0.042	0.028	0.003	0.0034
Sodium	45	52	30.3	38.65	0.962	0.513	0.715
Potassium	0.88	1.3	0.83	1.52	0.131	0.09	0.153
Calcium	22.7	27	26.4	69.32	2.45	2.228	6.30
Magnesium		14		53.6	2.0		9.25
Silica	17	18	15.4	10.37	0.29	0.211	0.167
Conductivity, micromhos/cm	400	359	574.5				
pH	7.1	6.9					

[a]Samples taken January 1972-July 1972.

[b]Samples taken July 1972-July 1973.

Table 3. Sod lysimeter water and nitrogen budgets, Mililani, 1973

Date	Rainfall (8-inch gage)	Irrig.	Percolate	Evapo-trans.	N addition	N percolate	N harvested
	----------------inches	-------------------			------------lb/acre	----------	
Jan.	0.93	14.70	4.55	6.51	54.90	0.421	14.25
Feb.	0.63	16.80	6.50	9.007	53.95	0.664	
Mar.	1.69	19.12	10.15	8.22	75.50	1.035	53.30
Apr.	1.13	14.97	6.23	6.98	62.60	0.635	67.45
May	1.58	16.94	10.29	9.07	87.00	1.05	
June	0.87	6.62	2.86	7.37	30.30	0.291	64.20
July	0.71	8.51	none	5.55	31.20	none	39.80
Aug.	0.90	7.70	10.57	5.781	37.23	5.58	
		9.75[a]					
Sept.	0.99	6.96	6.38	5.58	31.70	0.65	32.50
		3.33[a]					
Oct.	2.49	7.65	7.29	5.23	5.56	0.74	
Nov.	3.14	12.43	10.89	4.55	56.75	1.11	
Dec.	5.98	8.88	12.25	4.45	51.30	3.39	38.70
TOTAL	21.04	154.36	87.96	78.30	577.99	15.57	310.20

Water balance:

Rainfall	21.04 inches
Irrigation	154.36
	+175.40
Percolate	- 87.96
	+ 87.44
Evapotrans.	- 78.30
Net gain	+ 9.14 inches

Nitrogen balance:

N addition	577.99 lb/acre
N percolate	- 15.57
	562.42
N harvested	-310.20
	252.22
Estimate in roots @ 1/4 tops	- 78.00
Unaccounted	+174.22 lb/acre

= 174.22/577.99 = 30.1% unaccounted

[a]Tap water was used for a virus study in August and September only.

Table 4. Water budget of cane in field 246

Date	Rain-fall	No. rounds	Irrigation Lys. D[a]	Irrigation Lys. E[b]	Percolate Lys. D[a]	Percolate Lys E[b]	Evapo-trans.	Pan	Ratio, use/pan
	inches		----------------	----------------	inches	----------------	----------------	----------------	----------------
1973									
Feb.	0.63	2	6.50[c]	6.50[c]	none	none	7.13	6.017	rewetting
Mar.	1.69	1	3.25[c]	3.25[c]	none	none	4.94	7.369	0.672[c]
Apr.	1.13	2	6.50	6.50	2.03[c]	2.03[c]	5.60[c]	7.080	0.8[c]
May	1.58	2	8.00	8.00	2.78[c]	2.78[c]	6.80[c]	8.509	0.8[c]
June	0.58	2	8.40	8.40	2.15	3.85	6.83(D)	7.778	0.879
							5.13(E)		0.658
July	0.93	2	7.77	15.38	1.30	6.57	7.40(D)	8.481	0.873
							9.74(E)		1.148
Aug.	0.89	2	8.14	10.32	none	3.94	9.03(D)	8.193	1.10
							7.27(E)		0.888
Sept.	0.99	2	8.88	8.88	0.185	1.480	9.695	7.450	1.30
							8.390		1.125
Oct.	2.49	2	7.77	7.77	1.777	4.45	8.48	7.265	1.167
							5.81		0.80
Nov.	3.14	1	4.44	4.44	2.89	2.59	4.69	4.371	1.068
							4.99		1.138
Dec.	5.98	1	4.00	4.00	4.89	7.93	d	4.469	1.237
							d		0.557
1974									
Jan.	8.94	0			10.00	8.13	4.46(D)[d]		
							3.29(E)[d]		
Feb.	3.28	1	4.44	4.44	4.81	4.65	2.91(D)		
							3.07(E)		
Mar.	5.80	0			4.03	3.97			
TOTAL	38.05		78.53		36.85				

Apparent use, inches/day:

Month	Lys. D[a]	Lys. E[b]
		0.314
		0.234
		0.280
		0.188
		0.168
	0.072	0.053
	0.104	0.109
July-Dec.	0.259	0.236

Water balance:

Rainfall	38.05	inches
Irrigation	78.09	
	+116.14	
Percolate	− 36.85	
Net apparent use	+ 79.29	inches

Percolate/irrigation = 36.85/78.09 = 47%

[a] D = Ditchwater irrigation.

[b] E = Effluent irrigation.

[c] Estimated values.

[d] Combines December 1973 and January 1974.

Table 5. Analysis of crop log samples, February 12, 1974[a]

Plot	Avg sheath wt/stalk	Sheath H_2O	Blade N	Sheath					$K-H_2O$	API[b]
				P index	K index	Ca index	Mg index	Total sugar		
	g			percentage--------------						
Treatment A; ditchwater 24 mos.; 380 lb. N/acre										
16	71.6	84.6	2.00	0.075	2.87	0.28	0.157	9.6	0.47	1751
14	65.4	85.6	2.08	0.075	3.26	0.31	0.183	7.4	0.50	1677
5	57.8	84.6	2.08	0.087	2.74	0.33	0.187	11.0	0.44	2553
8	53.8	83.7	1.90	0.101	2.81	0.33	0.174	12.5	0.47	3492
9	70.8	84.9	2.10	0.084	3.30	0.30	0.156	9.3	0.53	1806
12	72.4	84.9	2.16	0.085	2.61	0.33	0.207	10.4	0.41	1621
19	54.8	85.6	2.18	0.079	3.11	0.31	0.189	8.1	0.48	2306
23	72.4	85.1	2.02	0.086	2.97	0.31	0.169	9.8	0.46	2132
30	66.8	84.8	1.92	0.086	3.31	0.35	0.115	10.0	0.53	2373
28	71.0	85.1	1.98	0.081	3.24	0.28	0.137	8.3	0.52	2181
AVG	65.6	84.8	2.04	0.084	3.02	0.31	0.167	9.6	0.48	2189
Treatment B; effluent 24 mos., ditchwater 12 mos.; 475 lb. N/acre										
15	69.8	83.7	2.02	0.085	2.65	0.34	0.197	12.0	0.45	2108
17	65.8	85.4	2.00	0.085	2.72	0.34	0.229	9.8	0.42	2121
4	60.6	85.5	2.12	0.093	3.06	0.30	0.173	9.4	0.47	3241
6	59.0	83.7	1.92	0.076	3.02	0.30	0.198	8.8	0.53	2183
10	68.0	84.5	2.08	0.084	2.24	0.35	0.208	11.0	0.36	2181
13	65.0	84.3	2.08	0.088	2.86	0.29	0.183	10.0	0.48	2453
21	72.6	85.3	2.16	0.094	2.84	0.35	0.187	10.7	0.43	2920
22	71.4	84.3	2.16	0.076	2.61	0.33	0.195	11.2	0.43	1763
26	62.0	84.7	2.06	0.087	2.97	0.30	0.178	12.0	0.47	2364
27	74.6	84.6	2.30	0.090	2.43	0.33	0.204	11.4	0.39	2046
AVG	66.8	84.5	2.08	0.086	2.74	0.33	0.195	10.6	0.44	2338
Treatment C; effluent 24 mos.; 413 lb. N/acre										
	64.0	85.5	2.14	0.093	3.64	0.31	0.157	10.0	0.55	2271
2	69.2	83.7	2.06	0.076	2.79	0.29	0.173	11.9	0.47	1714
3	75.0	85.5	2.20	0.098	3.21	0.28	0.173	9.7	0.49	2855
7	53.8	84.1	2.12	0.079	2.93	0.33	0.179	11.4	0.49	2463
11	75.6	84.6	2.02	0.097	2.80	0.29	0.171	13.0	0.44	3092
18	76.2	84.7	2.18	0.088	2.51	0.33	0.191	11.6	0.40	2295
20	68.6	84.3	2.16	0.087	2.26	0.36	0.210	11.6	0.37	2865
24	71.2	84.0	2.08	0.081	2.12	0.36	0.202	14.2	0.34	2109
25	71.6	83.8	2.02	0.092	2.18	0.37	0.251	15.7	0.35	2333
29	71.0	84.9	2.02	0.074	2.74	0.37	0.192	8.8	0.44	2178
AVG	69.6	84.5	2.09	0.086	2.72	0.33	0.190	11.7	0.43	2417

[a]Source: Hawaiian Sugar Planters' Association, Agronomy Department, Honolulu, Hawaii, March 14, 1974. Oahu Sugar Company, Ltd., Expt. 338 WD Sewage Effl., Series 5, Fld. 246, Crop Age 12.1 mos. Date sampled: 2/12/74; Date received: 2/25/74; Date of report: 3/14/74.

[b]Amplified phosphorus index.

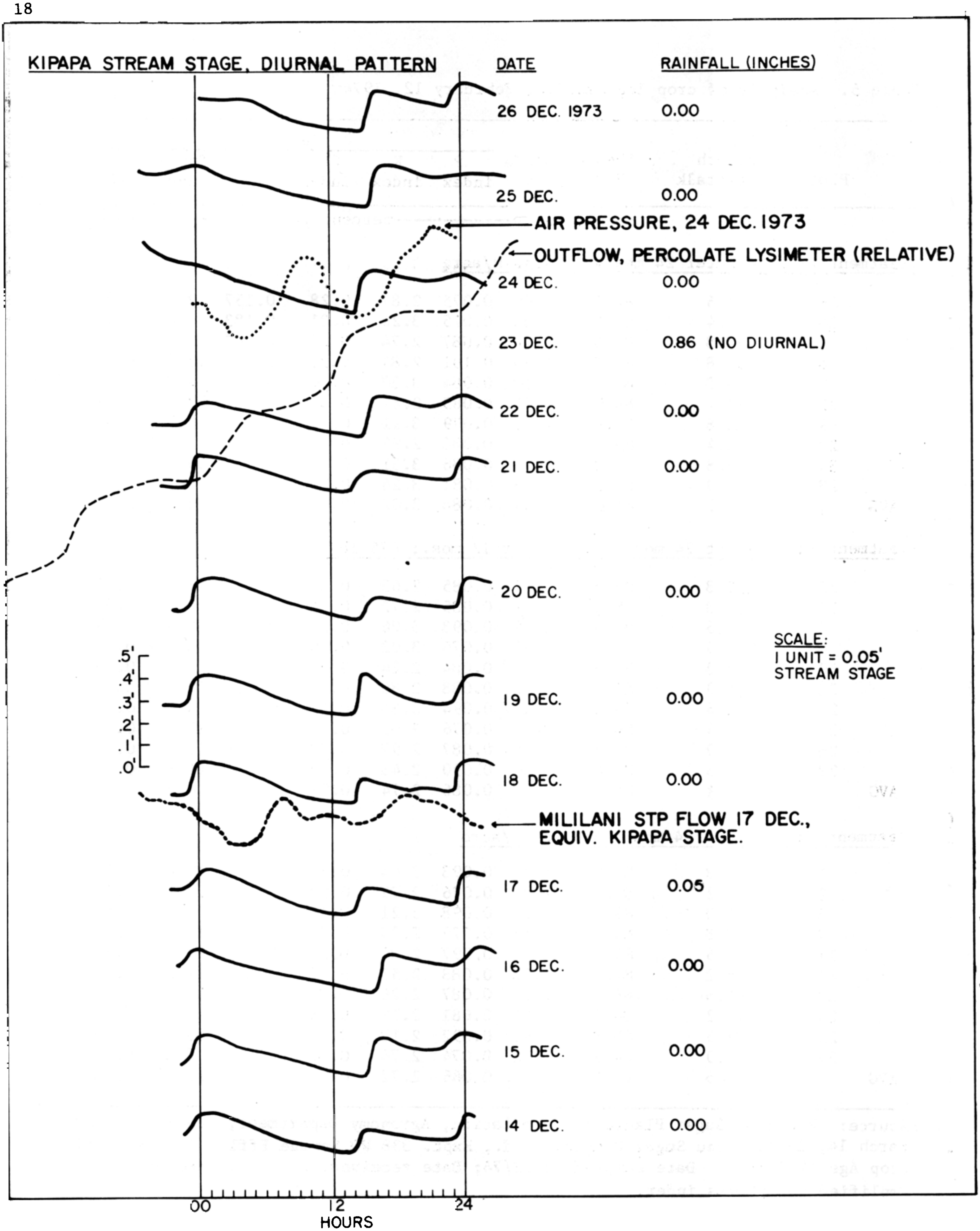


FIGURE 1. Kipapa Stream stage, diurnal pattern, December

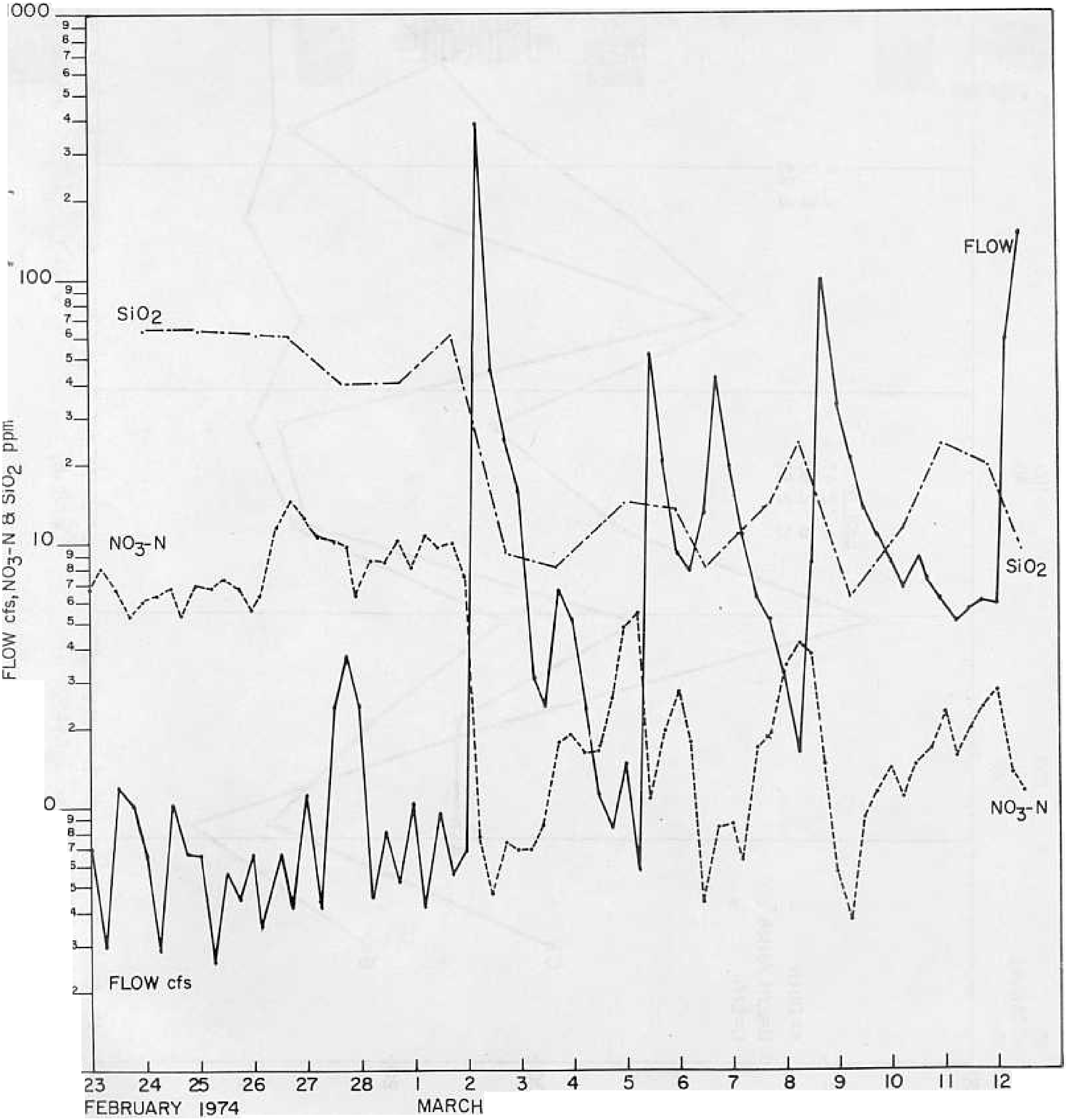


FIGURE 2. Kipapa Stream flow, NO_3-N and SiO_2 contents, February - March 1974.

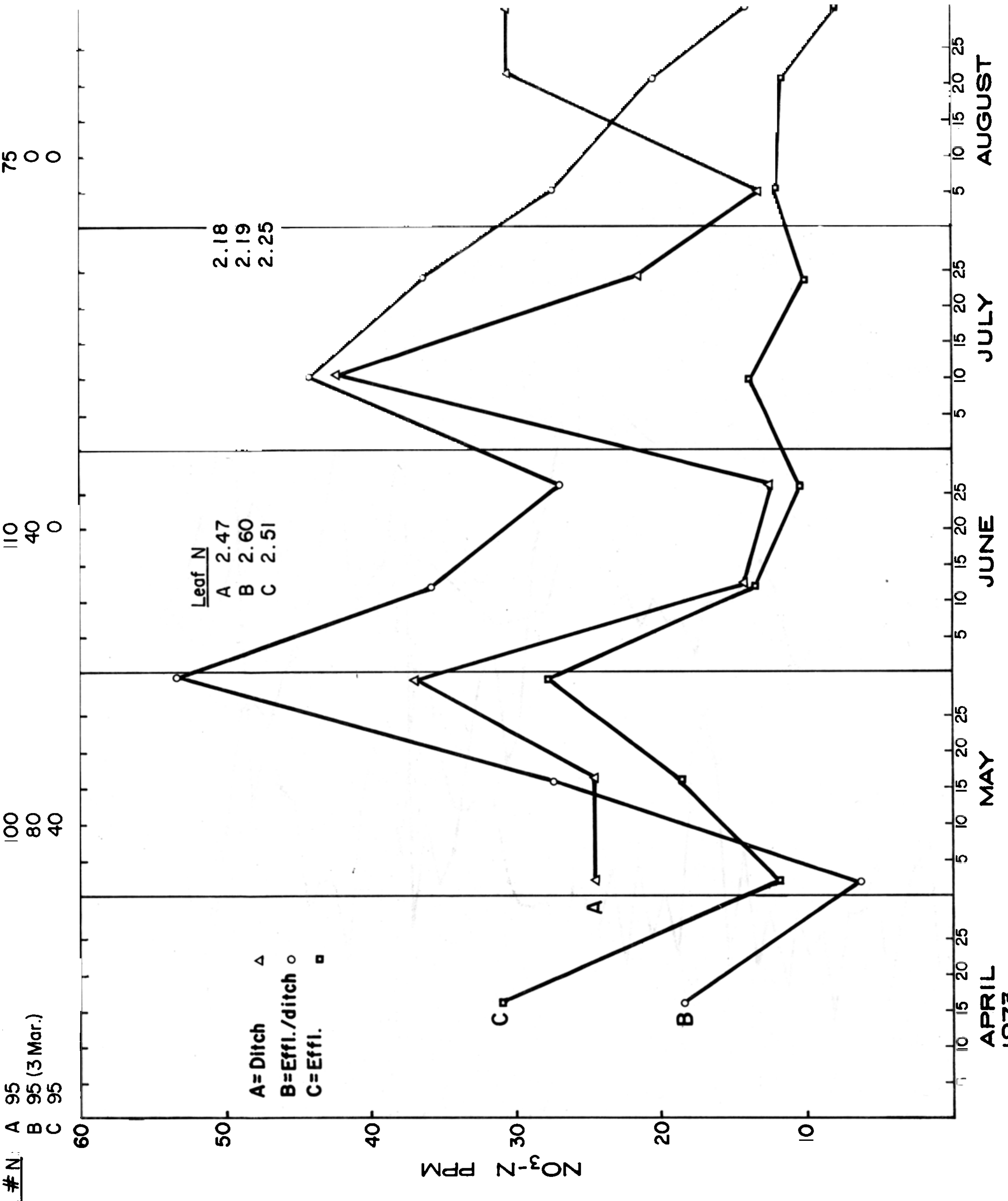
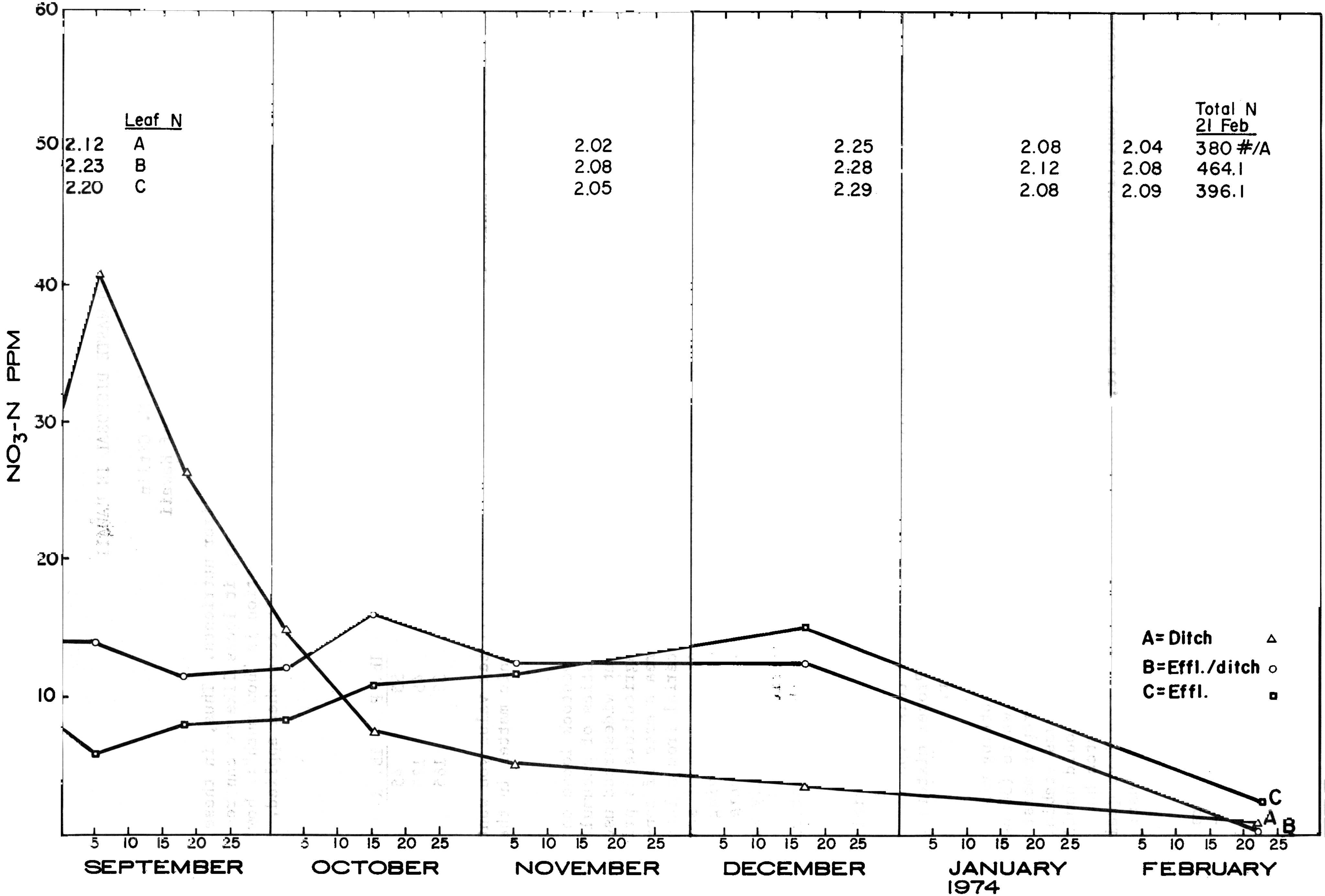


FIGURE 3. Nitrate nitrogen water extract, ceramic points, at 9 to 12 inches in furrow, Oahu Sugar Company, Field 246, April 1973 - February 1974.

C only : 20.3


NO3-N PPM
60
50
40
30
20
10
Leaf N
2.12 A
2.23 B
2.20 C
2.02
2.08
2.05
2.25
2.28
2.29
2.08
2.12
2.08
2.04
2.08
2.09
Total N
21 Feb
380 #/A
464.1
396.1
A= Ditch
B=Effl./ditch
C=Effl.
C
A
B
5 10 15 20 25
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
1974
FEBRUARY

SOLID WASTE DISPOSAL IN HAWAII

Harris M. Gitlin
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Plant and animal wastes are a source of fertilizer nutrients. Thus, in these times of a fertilizer shortage and a problem with wastes, it looks like we can relieve both problems at one time--and we can. The big question is "how much": how much fertilizer is available from wastes, and how much does it cost when applied, and how much is it worth in production?

Here is an estimate of how much is available in raw waste:

	lb. N	lb. P	lb. K
1000 lb. of layers produce in one year:			45
1000 lb. of hogs produce in one year:			125
1000 lb. of dairy cows produce in one year:			165

You can figure the animals per acre to get any equivalent fertilizer value you want. There are other values not shown, such as the effect of added organic matter in the soil on crop production.

Now, the cheapest way to spread this manure is to turn the livestock loose on the soil, and we're back where commercial agriculture began. The logistics of accumulating the waste, transporting it, and spreading it generally ruled out widespread use in the near past. In this connection, note that the practice of agriculture is primarily that of very thinly and uniformly spreading over a large area a mass of concentrated material, and then accumulating a very thinly spread material from a large area and piling it in a compacted space. In the meantime, 500 tons per acre of soil have been torn apart and rolled over for each crop. We think nothing of removing 500 tons per acre of rainwater overnight (6 inches) or spreading 13 tons per acre (1 inch) of water very uniformly over that acre. The logistics of manure really seem small compared to what is already being done. As a matter of logistics, liquid handling for accumulation, transport, and redistribution is usually the simplest and cheapest.

There is a large, and I think expanding, market for a stable organic material called compost, a potting soil component. We import much of this material used locally at present. One of the problems with our local products of this type is its variability, usually because of what I'll call "wild composting." Proper mixtures, properly mixed and processed, can be uniform in texture and character.

One local chemical company was interested in the potential of a potting mix market. We composted steer manure (50 percent) and school lunch paper waste (50 percent) under aerobic conditions. With the addition of urea and at the proper moisture range, we produced a satisfactory material in 3 weeks. The end product was stable, gave no evidence of its origins, and had a "good soil" musty odor. You could handle it all morning and then eat your lunch without washing your hands. One batch had considerable quantities of bagasse in it, added to reduce moisture. I believe quality compost production can be profitably produced here, particularly by an industry that already has sales and bulk transport facilities.

Most fertilizers have a certain amount of inert materials in them as carriers or bulk. You add this bulk at some cost. It is possible to use some form of composted material, waste if you will, to make up this bulk, and the added material can be produced locally. How many tons of inert materials do you use annually in the fertilizers sold in Hawaii? This has already been done; the problem is to make it economically feasible. I believe the required logistics of disposing of the waste, when added as a deduction to the cost of utilization, will make utilization feasible eventually. When we get there, processed wastes may be the "bulk" of your fertilizers.

An interesting situation is presented if you use composted waste as a filler. Fertilizer is sold by weight, and the nutrient content is based on percent by weight. But the density of compost may be in the order of 20 pounds per cubic feet, much lighter than most of the nutrients of bulk materials. Now, what are the legal and reasonable ways of handling this situation? Recall that most fertilizer distribution machines operate on a volume basis, even though they are calibrated in terms of pounds per acre. Our recommendations are in terms of pounds per acre of a particular formulation or of the three major nutrients. In this situation we would probably start by adding the lighter bulk to achieve the same volume as before. Thus a ton of 10-10-10 today would have the same volume and the same number of pounds of active ingredient as it has today. Then the calibration of all farm machines would still be valid. What you would do about the tag is another matter; perhaps it should be called "10-10-10 equivalent."

In 1970 I made a "paper analysis" of a system to handle all animal waste on Oahu. To be practical, I assumed that (1) 50 percent of all the waste actually got into this system, (2) the average haul was 20 miles to some one compost site, (3) the site was provided by the county, and (4) the operation was handled as a public utility because (a) it was under inspection by the State Departments of Agriculture and Health, (b) a producer was required to dispose of his waste in this manner, and (c) the producer was protected from lawsuits and complaints if he did dispose of his waste according to the rules provided.

The processer built all roads and structures on the site, purchased the necessary equipment, composted the waste aerobically, and could sell it at the site in bulk or bag. Estimating all costs, the final product could be sold at the site for about one-half the market price of the lowest cost material on the market at the time and still make a profit. The volume of material produced probably exceeded the current consumption, but not the potential consumption at a lower price; at that time we did not consider the potential of this bulk added to fertilizers.

There are other uses for this waste, and energy production is one of special interest, particularly methane production. Another potential use is processing for refeeding to animals. Investigations are being made in the use of both vegetative and animal wastes as a feed for livestock. Some of the early work was done here using poultry wastes. It has already been demonstrated that 20 percent or more of the ration of some livestock can consist of processed livestock waste. The economic potential for this approach looks good, particularly here where feeds are imported.

I don't believe there will be <u>one</u> answer; eventually, all of these uses will be made of our waste here. The criteria are mostly economic and can change rapidly, as you have seen. Research is the catalyst that can make economic value out of today's waste.

HEAVY METALS IN WATERS, SEDIMENTS, AND SOILS OF HAWAII

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The awareness of the public to pollution of various forms has become a significant development in recent years. A quantitative measure of this pollution is needed in order to provide factual data. The study to be reported is part of a much larger project sponsored by Sea Grant entitled "Quality of Coastal Waters," which was initiated to assess the magnitude of any contamination of our coastal waters and to devise means of protecting these waters.

How is this subject appropriate to a fertilizer conference? Our specific participation involved an attempt to answer the question of pollution by heavy metals. These metals were, in decreasing order of toxicity, arsenic, mercury, cadmium, lead, chromium, nickel, copper, and zinc. Of these, copper and zinc are micronutrients essential to plant growth of crops such as pineapple. Arsenic compounds have been employed as herbicides and mercury compounds as plant sterilants in Hawaiian agriculture.

A report made in October 1970 by the U.S. Geological Survey on selected minor elements in surface waters throughout the United States (1), which was initiated by the current interest in mercury in various water sources, showed that streams and drainage canals in Hawaii have been found to contain nondetectable amounts of arsenic, cadmium, cobalt, and lead and traces of zinc (0-20 ppb). Traces of mercury, 0-1.2 ppb, were found in water-sediment mixtures. These values are either similar to or less than those reported for other areas in the United States. Zinc appears to be present in highest concentration throughout the nation's surface waters, with values generally up to 200 ppb and even higher for some samples. Lead was found in most of the samples particularly in streams below metropolitan-industrial areas, indicating the probable effect of auto emissions. Despite the fact that certain heavy metal sprays have been employed in agriculture in Hawaii, this survey showed that Hawaiian waters contain relatively low values as compared to areas where heavy industries are predominant. Average values for arsenic, lead, and zinc in Michigan, for example, are 8, 4, and 104 ppb as compared to nondetectable levels of arsenic and lead and 6 ppb for zinc in Hawaii.

An important factor in the consideration of heavy metal pollution of water is whether the occurrence is man-made or natural. Hawaiian soils may be high in chromium nickel, copper, and zinc minerals (2-5), which may influence the levels of these elements in water, depending on their solubility. Solubility is generally low, however, for the minerals of heavy metals at the pH of water. A better indication of the possibility of pollution by heavy metals would therefore be an analysis of sediments together with an analysis of adjacent soils to ascertain the contribution from this source.

This report summarizes the chemical analysis of water, sediment, and soil samples from three coastal areas in Hawaii--a relatively unpopulated area (Kahana Bay), a residential area (Hawaii Kai), and a former sugar plantation location (Kilauea). A limited number of analyses is also given for several other local areas of interest. The relationship of the chemical data with the environmental nature of the samples is discussed.

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[1]With the assistance of Ada Chu, Junior Soil Scientist, University of Hawaii.

Sampling

Kahana Bay, Oahu

Located on the northeastern shore of the Island of Oahu, this site was selected because of its comparative freedom from population stress. As it was considered to be relatively pollution-free, it served as a baseline site.

Coastal soil samples were taken some distance into the valley and sediment and water samples taken at varying distances seaward, as shown in Figure 1. Soils were sampled once and water and sediments 10 times at monthly intervals at each station.

Hawaii Kai, Oahu

Situated on the southeastern end of the Island of Oahu, this site has developed into one of the most popular residential areas in Hawaii. Formerly a fishpond, the marina is practically an inland lake with spits of populated land jutting into it. As shown in Figure 2, soil samples were taken above the marina and water and sediments sampled within the marina and progressively out to sea. Over a 9-month period, water and sediment samples were taken at monthly intervals at each station. Soils were sampled once.

Kilauea, Kauai

This is the site of a sugar plantation that was closed in 1971. Located approximately 1 mile from the coast, the mill is surrounded by growing cane. Water and sediment samples were taken along the coastline, as shown in Figure 3, at 3 to 7 sampling dates over a period of 13 months. Soils were sampled once in adjacent areas.

Miscellaneous Sites

Occasional exploratory samples were taken from various shoreline areas on Oahu and Kauai. These are described in Table 3.

Sample handling and storage

Water samples were collected in gallon-sized polyethylene bottles. Aliquots were taken within 24 hours of sampling for the various analyses. Soil and sediment samples were stored in plastic bags. All samples were stored at 40 to 45° C until analyzed.

Analytical Methods

Most of the analytical methods were those described by the U.S. Geological Survey (6). To avoid interference by sodium from seawater, heavy metals in the water samples were chelated with ammonium pyrrolidine dithiocarbamate followed by methyl isobutyl ketone extraction and atomic absorption spectrophotometry. For zinc analysis, chelation and extraction were unnecessary because of the high-absorption sensitivity of the element in the flame. Mercury was determined by flameless atomic absorption(7) and arsenic by colorimetry with silver diethylidithiocarbamate after liberation as arsine.

Sediments and soils were dissolved by digestion with 2 + 1 nitricperchloric acid mixture. A few soils that contained color bodies resistant to the acid treatment were digested in platinum dishes with hydrofluoric acid to remove silica, and the residues were treated by dissolution with hydrochloric acid in the usual manner. The solutions were analyzed for heavy metals in the same manner as the water samples except that, due to the higher concentrations, chelation and extraction were unnecessary. To avoid the possibility of volatilization of mercury during digestion, a separate sample was refluxed with nitric acid and potassium permanganate for mercury analysis.

Distilled water was passed through Dowex 50-X8 cation exchange resin before use in all analytical operations to eliminate all traces of cations.

Results and Discussion

Water Samples

The analytical data on both sea and fresh water samples show minimal amounts of heavy metals (Table 1). The content of most of the metals did not exceed those reported for seawater. The insolubility of heavy metal-containing minerals is doubtless in large measure the cause for the apparent low content in water. Although zinc values in fresh water exceeded that found in seawater in a few instances, they were low compared to data on similar samples in other states, where zinc values often contain several hundred ppb (1).

Sediments and Soils

Kahana

Examination of the data on sediment and soil samples from Kahana (Figures 4A and 4B) clearly shows the influence of soil composition on that of sediments in adjoining coastal areas. A decreasing gradient in concentration in the sediments of elements present in relatively large amounts is seen in the values for nickel, chromium, copper, and zinc as sampling progresses toward the sea. In general, the concentrations of these elements in the sediments appear to parallel those in the soils. Samples Ka6 to Ka5 contain noticeable amounts of soil while Ka4 to Ka1 appear to be predominantly sand.

The elements in lower concentration--lead, arsenic, cadmium, and mercury--do not present a similar pattern of distribution. The higher lead values show an interestingly uniform distribution throughout the sediment and most of the soil samples, indicating the possibility of a homogeneous atmospheric deposition, such as that resulting from auto exhaust discharges. That these levels in sediments are toxic to fish is unlikely as levels as high as 25 ppm in solution have been found to be required to adversely affect the growth of trout (8). Despite this finding, lead appears to present a potentially serious pollution problem because of the large amounts being daily injected into the atmosphere as tetraethyl lead in gasoline. In a small area of 86 square miles in a watershed eco-system in the Champaign-Urbana area of Illinois, the output of lead from automobiles is estimated at 5150 pounds every 30 days (9). About 2 to 3 percent of the lead enters the water system, and the rest accumulates in stream-bottom sediments, soils, and biota. Continued monitoring of atmospheric lead and plant- and soil-absorbed lead is to be advised, together with toxicological experiments with lead-containing foods.

The high concentration of arsenic in the Kahana soils (293 ppm) was traced to the application of arsenic herbicide in the past. Levels in the sediments are low in comparison and indicate fixation of arsenate in the soil in a manner similar to phosphate soil fixation. Compared to the content of mercury and cadmium, however, arsenic levels of 10 ppm average at least ten-fold higher.

Of all the heavy metals determined in the Kahana sediments and soils, mercury was found in lowest concentration, at 0.06 to 0.40 ppm, followed by cadmium, at levels of 0 to 1.5 ppm. It is fortuitous that these two highly toxic elements are present only in trace amounts.

Hawaii Kai

Heavy metal analysis of Hawaii Kai sediments show generally higher values than either Kahana or Kilauea (Table 3). The influence of soil on sediment composition is again evident, and a decreasing gradient in concentration is seen for nickel, chromium, copper, and zinc in samples taken from coast to sea (Figures 5A and 5B).

Lead, arsenic, cadmium and mercury do not show this pattern of distribution. As with the Kahana samples, lead was relatively high and uniform in concentration throughout the sampling stations, whereas arsenic, cadmium, and mercury were present in trace amounts. The use of domestic weed sprays very likely accounts for the presence of arsenic.

Kilauea

Although soil composition in this area showed the highest values for heavy metals, sediment analysis gave values similar to the low values found for the Kahana samples (Table 3). Tidal action resulting in appreciable dilution of soil sediments very likely accounts for levels lower than those at Hawaii Kai.

Sediment lead values as a percentage of soil lead are much higher than the other macroelements, indicating again the possibility of an external source for lead, such as auto exhaust.

The high arsenic values may be indicative of past arsenic herbicide applications to this area (Table 2). Both cadmium and mercury values are present in trace amounts only.

Miscellaneous Locations

Miscellaneous samples from various locations of interest are listed in Table 3. Harbors where there is the possibility of pollution by discharges from vessels of all types contain the higher concentrations of various elements. Some of these high values, such as chromium, however, may be related to high soil values. The high chromium in Nawiliwili Harbor, for example, may be directly related to its concentration in adjacent soils. However, the high copper value of 1164 ppm at Kapalama is very likely due to pollution. Other high values in this category are nickel, chromium, zinc, copper, and lead in various locations.

Pollution Ratio

How to differentiate natural pollution from soil and foreign pollution of various kinds is proposed herewith. Ratios of the metal in sediment to the metal in soil are considered. If a sediment is essentially a soil, a ratio of 1 is obtained. Anything less than 1 may or may not be polluted by foreign material, but a ratio greater than 1 would definitely indicate some degree of foreign pollution. Table 4 presents ratios calculated from the data of Kahana, Hawaii Kai, and Kilauea showing ratios of less than 1, except for one value for lead and several for arsenic, cadmium, and mercury.

Because of the low cadmium and mercury values, the ratios for these elements may be subject to large errors. Arsenic values, however, are higher, and the indicated pollution at Hawaii Kai and Kilauea is considered real. The consistently high values for lead for all three locations indicates probable pollution by lead from auto exhaust. It is interesting to note that in the case of lead-auto emissions into the atmosphere, pollution of both sediment and soil occurs, which means that a ratio greater than 1 could never be attained. In this case, comparative ratios from adjoining nonpolluted areas would be a solution to this problem. It would be of interest to apply this simple calculation to data from areas having varying degrees of known pollution.

Summary

1. Analysis of coastal waters at Kahana, Hawaii Kai, and Kilauea for heavy metals shows, with few exceptions, nondetectable amounts of mercury and cadmium and traces of arsenic, lead, chromium, nickel, copper, and zinc well within published levels in seawater.

2. Similar analysis of coastal sediments shows traces of mercury and cadmium and small amounts of arsenic, lead, chromium, nickel, copper, and zinc. The levels of chromium, nickel, copper, and zinc indicate a definite relationship with levels found in the coastal soils. At Kahana and Hawaii Kai, a decreasing gradient of concentration from land to sea is evident, indicating a movement of minerals in this direction, largely due to rainfall and tidal action.

3. Lead, cadmium, and mercury in sediments and soils do not show this trend since their levels are relatively uniform. The proportionally higher content of lead in sediments than in soils may be indicative of an external source for lead. Monitoring of atmospheric and plant- and soil-sorbed lead is advised.

4. Arsenic in the Kahana sediments is approximately twice the concentration in the Hawaii Kai sediments. This is very likely due to the movement of arsenic from weed sprays applied to the cultivated Kahana coastal soils, where arsenic levels are up to 290 ppm. Since Hawaii Kai coastal soils show no arsenic, the levels found in the sediments may originate from domestic weed sprays.

5. The ratios of the average sediment to the soil values of heavy metals show highes values for the Hawaii Kai area except for chromium. This may be due to a lower degree of tidal action, or it may indicate a higher degree of pollution occurring in the Hawaii Kai area where population growth has increased greatly in recent years.

6. Analysis of samples from miscellaneous coastal areas show that the areas having high industrial activity contain the highest levels of heavy metals.

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Table 1. Analysis of heavy metals in water samples at various locations

Element	Fresh water: Kahana Bay	Fresh water: Hawaii Kai	Fresh water: Kilauea	Sea water[a]
	Range, ppb[b]			
Ni	1-3	ND-1	ND	0.1-0.5
Cr	1-3	ND-2	ND-4	+
Zn	1-5	1-18	ND-3	5-14
Cu	3-4	1-3	ND-0.3	1-90
Pb	ND[c]	ND-3	2-4	4-5
As	ND	1-2	1-3	2-18
Cd	ND	ND-1	ND	+
Hg	ND	ND	ND	0.3

[a]Source of seawater data: Handbook of Chemistry and Physics, 45th Ed. Cleveland, Ohio, Chemical Rubber Co., 1964, p. F82.
[b]Range of averages of 3 to 10 monthly samples at various stations.
[c]ND = Not detectable.

Table 2. Heavy metal analysis of Kilauea coastal sediments and soils

Element	Sediments	Soils
	Range, ppm	
Ni	19-109	259-639
Cr	21-66	470-3652
Zn	6-48	84-218
Cu	6-16	58-255
Pb	20-26	40-76
As	3-19	-
Cd	1.6-3.2	ND-0.5
Hg	ND[a]-0.1	0.1-0.7

[a]ND = Not detectable.

Table 3. Average amounts of heavy metals in coastal sediments from various locations[a] in Hawaii.

Site	Ni	Cr	Zn	Cu	Pb	As	Cd	Hg
	ppm[b]							
Kahana Bay, Oahu	69	35	23	21	26	11	1.2	0.1
Hawaii Kai, Oahu	111	49	55	47	32	5	1.8	0.2
Kilauea, Kauai	50	40	26	11	23	10	2.3	0.1
Nawiliwili, Kauai	226	1208	94	68	56	-	ND[c]	0.3
Kapalama, Oahu	178	165	482	1164	252	-	1.3	1.3
Ala Moana, Oahu	170	159	338	211	151	-	1.8	1.2
Honolulu Harbor, Oahu	152	327	198	116	161	-	ND	1.1
Kaneohe, Oahu (Mokapu outfall)	156	23	33	13	26	5	2.9	ND
Waikiki, Oahu	38	17	7	4	37	-	0.7	0.1
Port Allen, Kauai	434	1369	132	66	55	-	ND	0.1
Kauai, Off McBride Plantation	33	27	44	12	20	-	0.7	0.1

[a] 1 to 23 sampling stations at each location and 1 to 10 monthly samplings.
[b] Oven-dry basis.
[c] ND = Not detectable.

Table 4. Average sediment-soil ratios of heavy metals at various sites in Hawaii

Element	Kahana	Hawaii Kai	Kilauea
	ppm		
Ni	0.21	0.55	0.10
Cr	0.67	0.12	0.03
Zn	0.18	0.51	0.17
Cu	0.17	0.29	0.08
Pb	0.59	1.10	0.42
As	0.12	--	--
Cd	1.33	--	24.00
Hg	0.50	2.00	0.27

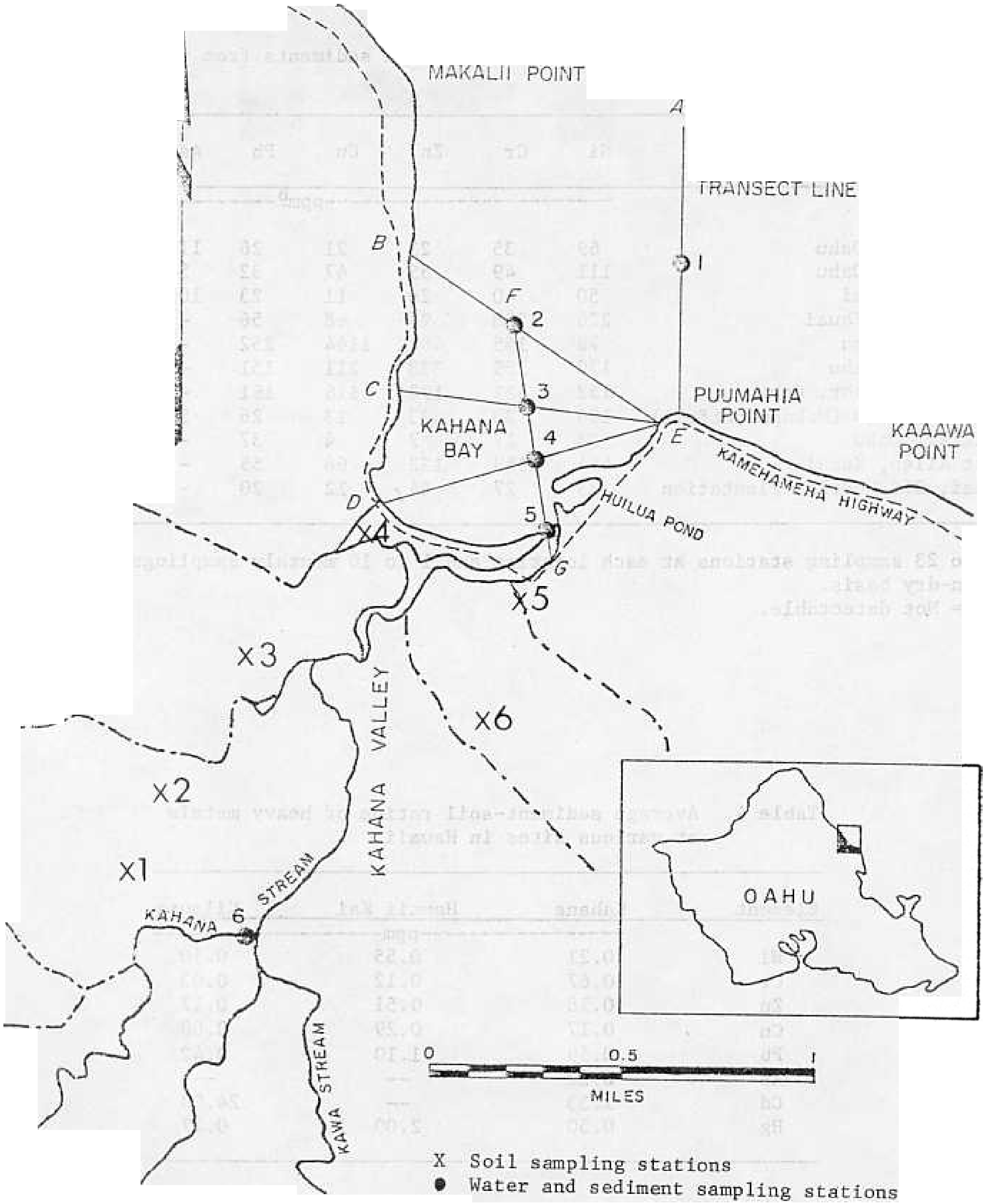
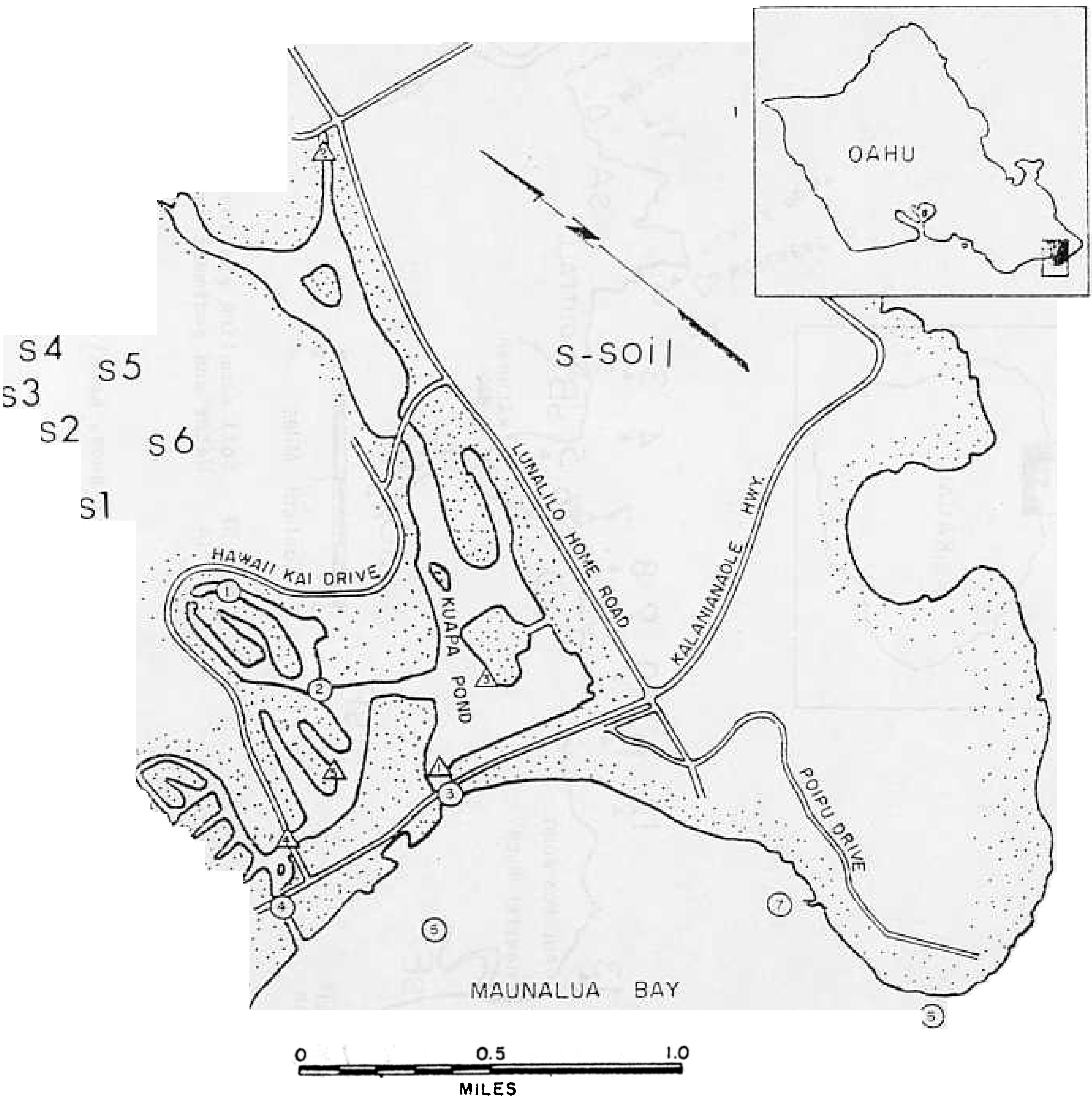
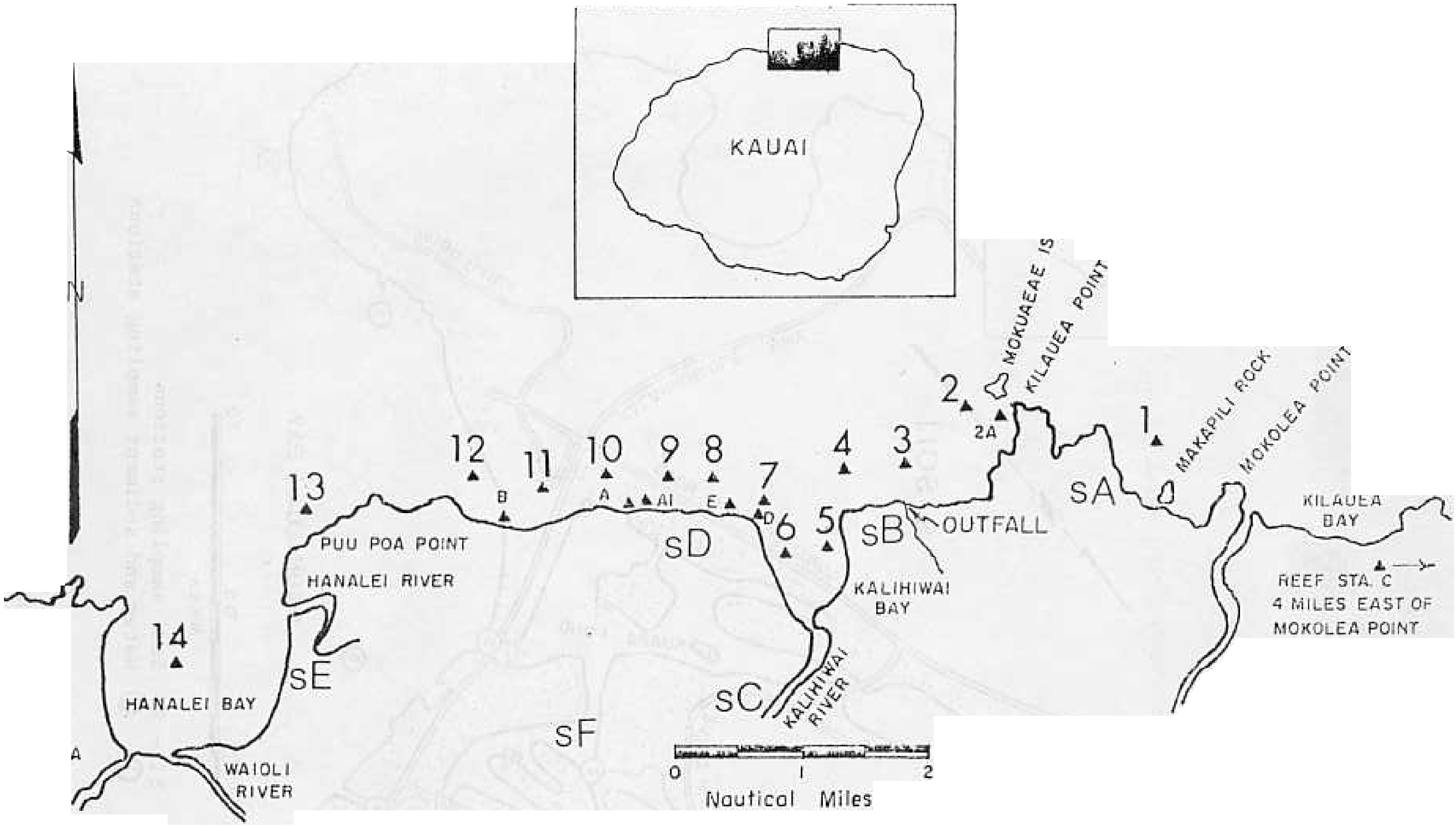


FIGURE 1. Site of soil, water, and sediment sampling at Kahana Bay, Oahu.



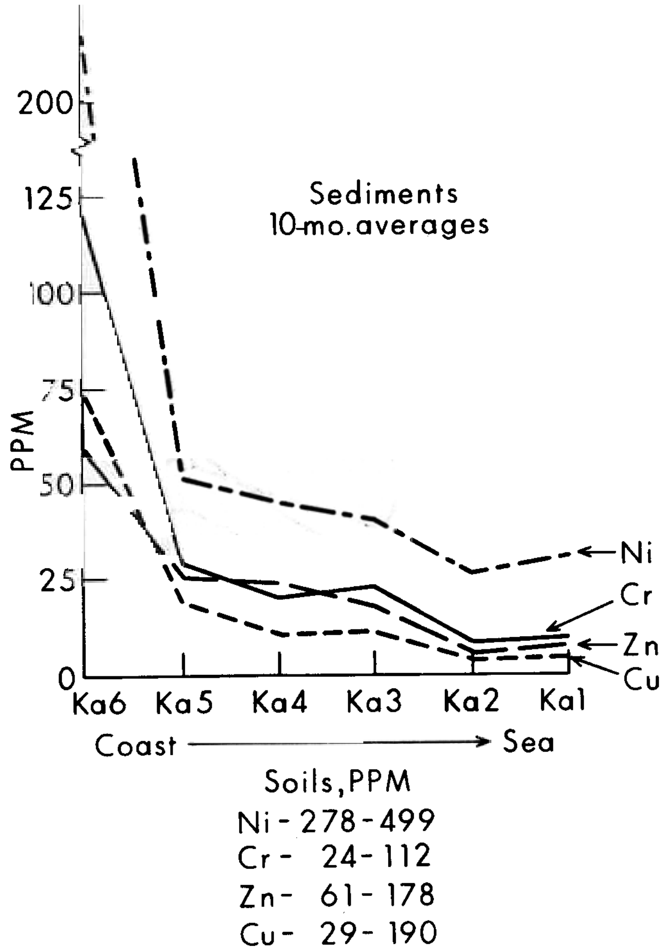
S1 - S6 Soil sampling stations
① - ⑦ Water and sediment sampling stations

FIGURE 2. Site of soil, water, and sediment sampling at Hawaii Kai, Oahu.

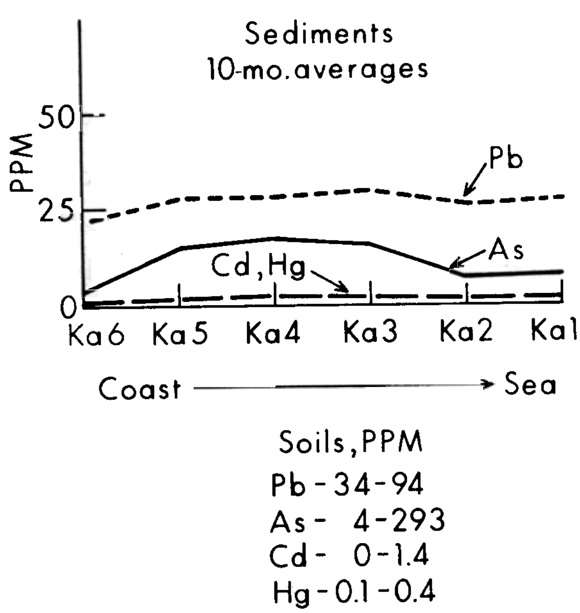


SA - SF Soil sampling stations
1 - 14 Water and sediment sampling stations

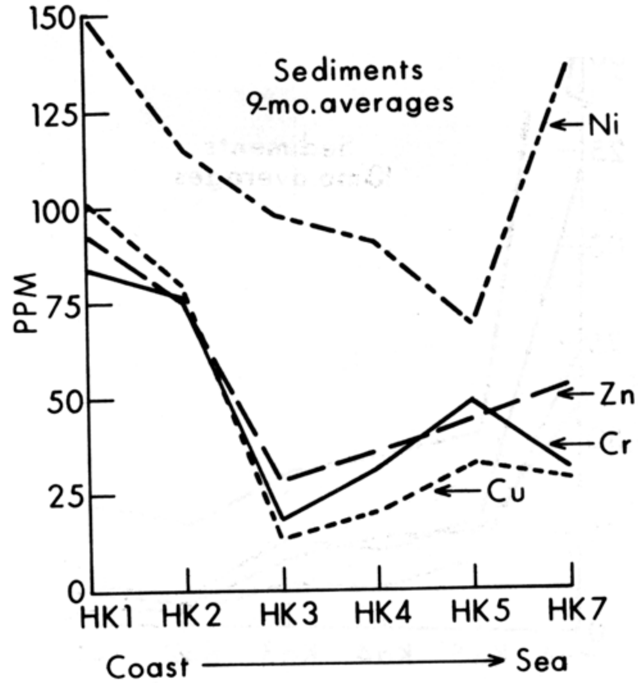
FIGURE 3. Site of soil, water and sediment sampling at Kilauea, Kauai.



:kel, chromium, zi and copper in sediments and soils at Kahana Bay.



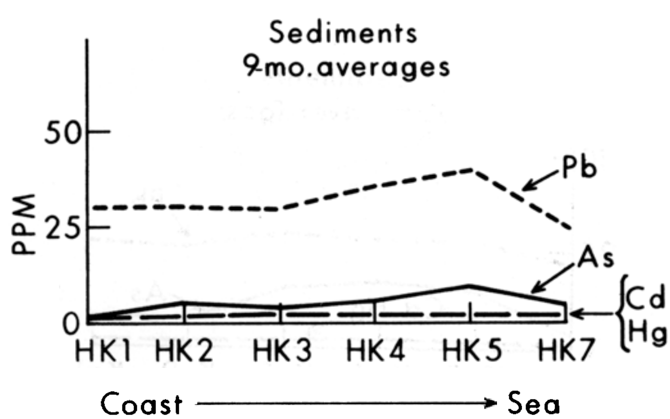
iments and soils at Kahana Bay.



Soils, PPM

Ni - 142 - 287
Zn - 93 - 125
Cr - 262 - 634
Cu - 126 - 187

IGURE 5A. Nickel, zinc, chromium, and copper in sediments and soils at Hawaii Kai.



Soils, PPM

ND = Not detectable

Pb - 23 - 40
As - ND
Cd - ND
Hg - ND - 0.2

FIGURE 5B. Lead, arsenic, cadmium, and mercury in sediments and soils at Hawai

NEW OPPORTUNITIES FOR AGRICULTURE

Frederick C. Erskine
State Department of Agriculture

First of all, I want to tell you what an excellent time this is for me to talk about opportunities for agriculture. We have had another terrific year in the State Legislature--the third straight year of strong legislative support for accelerated expansion of diversified agriculture, State-wide. I have also just returned from attending the American Food Festival in Tokyo, Japan, where Hawaii-grown papayas have found a big market.

The 1974 Legislature appropriated more than $16.5 million for various kinds of support of agriculture. This year, the Department of Agriculture set its sights on four key programs that we felt were the most critical to achieving the kind of agricultural development that we want. These were:

1. The start of State-wide water development for agriculture.
2. Planning of an interisland transportation system that would improve the distribution of agricultural products and supplies in the State.
3. Further support to our agricultural parks development program.
4. Continuation of funding for task force programs for Kohala, Kauai, and Molokai.

Water Development

Traditionally, as you know, the responsibility for developing water resources has been divided between the county (for urban needs) and the State (for farming needs). With the work of the State task forces, and specifically the Kohala Task Force, we are beginning to see the water problem attacked on an integrated basis--that is, to meet both farming and non-farming needs. The 1974 Legislature appropriated $5 million to start the State on a program of substantially improving water resources. This is a major financial and policy commitment on the part of the State Legislature to what we consider a major need. The impact of the program will be felt from Ka'u and South Point to Kona, Waimea, and Kohala; to the West End of Molokai; to the Kula and Makawao lands of Maui; to Ewa, Waimanalo, and Kunia here on Oahu; and to Kilauea on Kauai.

It is very obvious that adequate supplies of water are absolutely essential to agricultural productivity and development. We are embarked on a very ambitious program of expanding our farm productivity in order to achieve greater self-sufficiency for our State. In order to accomplish our goals for all sectors of farming, we must not only expand into new areas of production but also make the very best use of our farm lands. Much of these lands are incompletely used or as yet untried, and water is the key. When the farmer considers expanding production, one of the first things he thinks of is whether adequate agricultural water is assured.

There are many areas in the State where farming is very successful in normal years but, when the rainfall drops below the norm, then the farmer suffers economic loss. We have just gone through such an "abnormal" weather cycle, and the farmers in Kula, Makawao, Olinda, Volcano, Kona, Waimea, and Hamakua have suffered crop and livestock losses because of inadequate water resources.

The development of agricultural water supplies is appropriately the responsibility of government. There is much that the State can do to help the farmers with water problems. In the State-operated irrigation system, for example, we need to modernize and expand in ways that will adequately meet new demands. We urge our farmers to expand, and we help them to finance expensive water distribution systems on their farms, including stock water and all of the various new techniques of water irrigation. We should not have to tell these same farmers to observe water hours and limit production because of inadequately developed water resources in their area. The new appropriation will mean departure from the piecemeal approach to water development. With adequate funding, we can now plan comprehensively to meet priority needs and agricultural expansion schedules, and we can better provide water at rates structured to maintain reasonable crop production costs.

In addition to the traditional approaches to developing surface- and ground-water resources, we also have the appropriation now to balance the development of new water resources with the recycling of waste water. This, then, is the significance of the Legislature's $5 million water development appropriation.

Interisland Transportation

Another major constraint to agricultural development is the cost and adequacy of interisland transportation. Neighbor Island farmers find it hard to compete with Oahu farmers because it costs $0.065 to ship a quart of milk to Oahu from Hawaii, about $0.025 to ship a dozen eggs from Hilo to Honolulu, and $0.005 per pound to ship tomatoes from Maui to Honolulu. These are costs that Oahu farmers do not have. In some cases, other costs are higher on Oahu than on Neighbor Islands and these can partially offset transportation; however, there has not been an exodus of farmers to the Neighbor Islands nor has there been massive agricultural developments showing that freight costs exceed the offsets. The pineapple phase-out on Molokai is a complex situation, but freight to Oahu is one of the main reasons for the decision to phase Molokai out.

Another problem is the adequacy of surface transportation. The State or county has task forces working on the agricultural lands that are available on Molokai and Kauai and at Kohala. There is only twice-weekly service to Kauai by Young Brothers, Ltd. Frequency should be three or four times a week to move fresh and perishable items to Oahu for her needs. There is only twice-a-week service to Molokai, and it should also be three or four times a week. It will be necessary to have adequate frequency of services, as well as low rates, for farming to develop on these two Islands, as well as on the others.

Transportation also hampers agricultural development of export crops. Kauai has weekly container service, but it is unreliable in that the schedule is often altered. It is virtually impossible to ship perishable products because of spoilage problems. Processed products are difficult to ship because of missed connections in Honolulu. Kauai has a severe problem, but Molokai's is worse. That Island does not possess a deep-water harbor, so all freight to and from the Mainland must be transshipped by interisland barge. Molokai needs either a deep-water harbor or a through-rate system utilizing interisland barges that will allow it to compete with other Islands that presently enjoy through service by the deep-water, interisland, container ship.

An adequate interisland transportation system is what it will take to make total agricultural development on all Islands work. It spells the difference between an integrated State of mutually reliant Islands or a loose collection of Island communities that cannot count on adequate mutual support.

Agricultural Parks

To a farmer, land and opportunity are virutally synonymous. Taking away his land obviously means that you are taking away his opportunity. On Oahu we have seen that painful and wasteful retreat of farmers from their farmlands because of urban encroachment. On Oahu, the farmers' most pressing problem is finding good farmlands safe from urban encroachment. On the Neighbor Islands, there is also a great need for farmlands with good lease terms. The answer for many of these farmers in need of a place to farm is agricultural parks.

The 1974 Legislature appropriated $3 million to supplement an original appropriation of $1 million to insure the rapid development of a State-wide agricultural park system. Two agricultural parks have been designated on State land on the Big Island--Pahoa and Kahei.

Oahu has the greatest need for agricultural parks because here is where agriculture faces the most immediate threat. Urban sprawl and pig farms don't mix. In spite of our best efforts, the writing is on the wall for a large number of our livestock operations if a secure and permanent refuge cannot be developed in fairly short order. Our dairy industry is practically under siege; the industry is threatened by new highway construction, encroaching subdivisions, and increasingly stringent waste handling and water quality standards. For preserving agriculture on Oahu, agricultural parks offer the brightest prospect.

The Department of Agriculture, in cooperation with the Department of Land and Natural Resources, has been moving rapidly to implement the agricultural park program. A preliminary Oahu Site Selection Study was completed in May 1973. In August, the Conceptual Design and Cost Comparison Study was received. Both studies examined the advantages and disadvantages of 10 specific sites on Oahu. On the basis of this research, it was determined that the Pohakea area in Kunia would be the most suitable site for the first agricultural park. We are also impressed with the Kahuku and Ewa areas and hope to develop agricultural parks there in the near future.

During October and November of last year, with the assistance of the Office of Environmental Quality Control, we circulated a draft Environmental Impact Statement assessing the Pohakea site. Last December we issued a revised EIS in the form of a supplement to the original draft.

The Department of Agriculture has been working with Campbell Estate, Oceanic Properties, Del Monte Corporation, and the Land Use Commission on acquiring an initial 500 acres at Pohakea. To date, we have a total of 62 applicants for the first park. As is required by Act 110 of 1972, first preference will be given to farmers displaced by encroaching urbanization. Our tentative schedule for the agricultural park on Oahu is:

May 1974	Begin process for AG-2 zoning.
	Release planning funds and begin engineering drawings.
September 1974	Review and revise drawings by appropriate agencies.
December 1974	Complete bid specifications and send out for bidding.
January 1975	Begin construction of on-site improvements.
July 1975	Farmers begin locating on site.

Task Forces

The 1974 State Legislature endorsed the task force approach, which is represented in the work of the State Kohala and Kauai Task Forces. This year, the Legislature provided a $5.2 million appropriation to Maui County's Molokai Task

Force. The Kohala Task Force previously received an appropriation of $4650 million; the Kauai Task Force received an appropriation of $4100 million. The action of the Legislature this year was merely to extend the lapse date of these two appropriation

In Kohala we see the Kohala Nursery, the largest export nursery in the State, well along in construction. The first environmental house has been completed and is stocked full of ornamentals in preparation for significantly expanded exports to the Mainland; a second environmental house is nearly completed, and it is being stocked as rapidly as the benches can be constructed.

Another huge export nursery, Orchids Pacifica, is just about ready to begin construction in Kohala.

Hawaii Biogenics has begun construction of their feedlot and heifer replacement center.

Feed grain research is progressing in Kohala, and grain facilities at Kawaihae will also be expanded to serve Kohala.

Because of the recent rise in the world's sugar prices, the Task Force is seriously looking into the feasibility of modifying and continuing sugar operations in North Kohala. These are the events taking place in North Kohala, and the prime mover has been the State's Kohala Task Force.

On Kauai, the State Kauai Task Force has tackled a very rough problem--putting Kilauea farmlands back into farming. Following the plantation closure, the lands were sold to essentially speculative and non-farming interests. A trust management plan is being drawn up for approval by the Task Force to allow some urban development to take place on relatively small, high-value "view" lots and to allow turnover of the bulk of the lands most suitable for farming to an agricultural land trust for leasing to farmers. If this plan succeeds, the Kauai Task Force will have reversed, for the first time, a major speculative land trend for the benefit of agriculture.

These were the problem areas--agricultural water development, interisland transportation, agricultural lands, and leadership. These are now being made into opportunities that will have direct benefit for agricultural development in Hawaii. It has taken just 3 years of hard work, fine cooperation, and the complete support of the State Legislature. With the kind of breaks we have had, I count on the success of agriculture in Hawaii today, and most definitely in the future. I believe we have rounded the corner, and agriculture is beginning to stand for opportunity rather than problems.

THAT'S NEW AND WHAT'S OUR CURRENT SITUATION IN FERTILIZERS?

Robert E. Stengle
Brewer Chemical Corporation

When I was first approached to address you, the suggested topic was, "What's New in Fertilizer?" Since that time, the supply situation of fertilizers has crystallized into a major problem, and, with your permission, I'd like to modify my address and give you a rundown of our current status as it applies locally and then launch into new fertilizer developments, also as they apply to Hawaii.

First of all, where do we stand? On the demand side of the equation there has been little change in the overall tonnage of fertilizers used in the past few years, and it is quite unlikely that any change in trend will develop. This, of course, is in sharp contrast to the situation on the Mainland. The reason for our flat tonnage demand is due to compensating changes in our agricultural industry. In certain cases where acreage of pineapple plantings has been eliminated, sugar has replaced it, and, in certain other areas, papaya has come on strong as a major thrust in diversified agriculture. Fertilizer tonnage loss to the pineapple and sugar industries has been supplanted by fertilization of the diversified agriculture farming and the increased fertilization of grazing pastures. Speaking for Brewer Chemical, the ideal situation would be to have all sugar and pineapple acreage in papaya since this crop uses far more fertilizer than the other two on a per-acre basis.

So with the demand relatively flat, what is our supply situation? As you all realize, Brewer Chemical supplies the largest portion of the fertilizer consumed in the Islands. Our suppliers are treating us well. We are considered a good customer for a number of reasons. First of all, we have a year-round demand as opposed to a seasonal mainland cycle. When our barge pulls into port, 100 to 150 carloads of materials roll out of their factories along with one invoice. Our level demand is not causing a sudden surge in their traditional customer pressures, and, finally, and most importantly, our industry for years, because of its dependence on long lead time shipping plans, has been required to forecast consumption. To my knowledge, this forecasting is unique in the United States, and, in this time of tight supply, our major suppliers accept our forecasts as realistic and dependable, and, therefore, they can plan production around them.

Now for a rundown of the various materials. Nitrogen, of course, is the commodity that is currently the shortest in supply and is expected to be short for the longest period of time. Our supply primarily comes from Canada, and our supplier is located next to a source of raw material, that is, natural gas, and has fairly definite expansion plans. The only major event that could disrupt our traditional source would be the frivolous placing of an embargo on exports by the United States government. If this should result in a backlash, counterembargo by the Canadian government, we would have major problems. It is unfortunate that our area of growing demand is for nitrogen because the available supply form of the nitrogen might not be as desired. At times, I feel we might have to substitute sulfate of ammonia for urea or for aqua ammonia.

As for our phosphate supplies, they come from Idaho and California. Our Idaho supplier is scheduled to have a plant expansion start up sometime next month. Our California supplier unfortunately is phasing out of fertilizer production. The material that we've been getting from California has a white phosphoric acid base, and the economics of producing this raw material is such that it is actually an economic waste to process it into fertilizer. The California material is the highly soluable 21-53-0 diammonium phosphate, which has formed the base for most of our solution fertilizers. We are currently experimenting with 18-46-0 diammonium phosphate as a substitute for this material, and we feel we are pretty close to solving this supply problem.

Potash raw material is in the easiest supply. Timing and types again are problems, primarily due to freight car shipping logistic difficulties.

In summary, we have a very tight situation on our hands that requires close attention. As to the prices, it is my sincere belief that you've seen the last of the major price increases caused by the major reshuffling of commodity values that we've just experienced. For phosphates and potash, I feel that we will be down to responding to inflationary lost pressures rather than to a market that has taken off. Nitrogen is another story, and I'm afraid crossing fingers and hoping are well in order since a clear crystal ball is not available.

Our other major supply problem, that is, shipping, seems to be well under control. It is indeed fortunate that a $6 million investment was made a number of years back in our 16,000-ton bulk barge and tug, for without this, we'd be dead right now. It is virtually impossible at this time to obtain vessels willing to take bulk cargoes.

Shipping costs are another headache. Last year, we used 1 1/4 million gallons of diesel fuel on the tug MacNaughton. Needless to say, we went through a number of tense moments during the recent fuel oil squeeze. Supply no longer seems to be a major problem, but take 1 1/4 million gallons of diesel and multiply it by the recent price increases, and you can see what we're up against cost-wise. We are attempting to offset this shipping cost inflation for fertilizer by carrying in our deep tanks other bulk commodities that we distribute, such as liquid caustic soda and aqua ammonia. This works out quite well when we have a light bulk-density cargo, such as urea, and allows us to fully utilize the barge rated capacity. We are also currently planning on shipping bulk liquid chlorine to the Islands on the barge and, therefore, will be getting away from the necessity of hauling full and empty chlorine cylinders between here and the Mainland.

In addition to this, we have invested over 1/2 million dollars this past year in our fertilizer storage, distribution, and production facilities located on each of the Islands. This is peanuts, however, compared to the added cost of carrying a higher priced fertilizer inventory.

What are the future products that we can expect to see? As you may well be aware, most of our new products are pioneered by the Tennessee Valley Authority, and I'd like to take my hat off to them at this time. They have helped us as individuals and helped our industry tremendously. New products that they are currently working on include granulated urea, which supposedly has twice the crushing strength of the prilled material. This could be a great boon to us, and I hope the material is less hydroscopic than the prilled. As to phosphates, about 2 years ago, TVA developed a process for making a 10-34-0 liquid fertilizer by reacting anhydrous ammonia with superphosphoric acid. Unfortunately, I don't think we'll see any of this in the Islands because of shipping difficulties. In addition, TVA is experimenting with an 11-57-0 granular material made from the less expensive phosphoric acid and a 28-28-0 urea ammonium phosphate also granular. We have written requesting samples of the materials but have not yet received them.

In addition to the TVA material, we are currently becoming more involved in organic materials in response to local demands. The best nitrogen and phosphate source is primarily sewage sludge, and, I hate to admit it, but the source of the organic potash that we're currently looking at is sugar beet pulp. We are starting to hear more and more that using garbage, solid waste, and other waste products for fertilization is the new thing. I was quite astonished when Bob Engelhard of our company presented me with an article about Pacific Guano and Fertilizer Company, our predecessor. The article appeared in a magazine called "The Sales Bulletin" and is dated January 1939. I'd like to read you an excerpt from it now.

> Presence in Honolulu of a full-fledged fertilizer works may mean satisfactory solution of the city's garbage problem, recently raising a stink politically and otherwise. Busy PG&F chemists are figuring a way to turn all city waste into plant food and other useful knicknacks They are now in sight of an answer, provided the City lets the wet go with the dry and the pigs go hungry or eat grain. Wet garbage yields fats, oils, potash, and other valuable salvage.
>
> Slashings and weeds, dry trash from residential grounds, parks, which now too often are burned to fill the neighbors' homes with smoke, sparks, and foul odors and their hearts with homicidal yearnings, will be carted away, ground up to make artificial, sterilized manure. Tin cans will be stripped of their valuable tin, their ferrous remains made into iron sulphate. Even glass, No. 1 waste pest, will be crushed, its silicate (of which Hawaiian soil has none) used to make local manufacture of building brick possible.

I'm sure that the article did not get a futurist's award for recognizing the problem before the worldwide scope of a crisis became evident as it is now. We are currently working with a number of firms along the lines described in 1939, and a number of the processes look quite promising.

Other new products under development include liquid fertilizers made from a base other than the traditional 21-53-0 and a solution to the question of how do we best fertilize under drip irrigation conditions. Contenders here are the Osmocote-type and a sulfur-coated material. Currently the products are developed, but the economics for widespread agricultural use are not quite with us. In addition, our research and development group is concentrating heavily on home and garden fertilizers formulated specifically for local soils.

In summary, the message I would like to leave you with contains two key words for overcoming our current fertilizer situation. These are "conservation" through proper application rate determined by testing, both soil and foliar, and "communications" through forecasting demands so that Hawaii can remain a steady, dependable customer in the eyes of our traditional basic manufacturers.

FERTILIZATION PROBLEMS OF STATE HIGHWAYS

Douglas S. Sakamoto
State Department of Transportation

When Dr. McCall asked me several weeks ago to address you this afternoon on the problems of fertilizing State highway property, I wondered whether I should come here to express my concern about the rise in fertilizer costs or to complement the manufacturers for their continued research in plant nutrition.

Hawaii is world renowned for its "natural beauty." Natural beauty that immediately brings to mind lush vegetation in a mild, tropical climate. This image of lushness is possible when plant material remains undisturbed by animals or other predators that would change the normal cycle of propagation and rehabilitation--where plant material would be returned to the soil and decompose to support succeeding generations of plant life.

With the invasion of man and his societal type of living, this normal cycle had to change. Man began to look upon plants as a resource to enhance his life to what he felt was an improvement toward civilization. Plants were grown to satisfy his needs for food, shelter, and clothing. This primary requirement led man to try to improve the production of specific plant materials in an effort to achieve more for his efforts and thus introduced our fertilizer industry.

Since this early beginning to the present, the emphasis has been on the cost-benefit to man in terms of dollars. In other words, the question has been, "How much can I get back on the dollar I am investing in growing this particular plant?" This question is easily answered by a farmer or a rancher, but it may require in-depth analysis by a hotel or restaurant proprietor who maintains a pleasing atmosphere for his clients. In either case, some dollar value can be attached to the plant materials grown.

Highway landscaping is a little more difficult to analyze on a dollar cost-benefit basis because of the many variables that enter into the analysis. These variables include (1) climatic conditions, (2) the soil or absence of it, (3) the adaptability of the plant material, and (4) the degree of growth desired based on an agreement of the standard of production.

The climatic conditions on State highways differ--from the dry, arid conditions of Waianae and the Kau desert to the cool, wet areas of Hawaii Volcanoes Park, Kokee, Haleakala, and the Kohala mountains.

The spectrum of different soils throughout the State is familiar to you, so I shall not delve into this except to say that, in highway construction, the soil is severely disturbed, and we are continuously having to contend with substrata conditions.

The adaptability of plant material is something over which we have some control. Although we have an overall guideline to blend our highway plantings into the surroundings, we also have need for accent areas, and the possibility always exists that the surroundings may change. This is especially true on Oahu where highways that once ran through pasture, cane, and pineapple lands are now bordered by homes and commercial buildings.

Agreements on the standard of production and the desired rate of growth are the most difficult variables that confront us. Who is to say that the Bermudagrass shall be this shade of green, the leaves on this tree shall be that shade, and that to achieve this particular color, we are justified in expending X number of dollars to buy and apply fertilizer, install sprinkler systems, and conduct all the necessary horticultural practices?

It is a standard practice for those in management to use the phrase, "no money." This is especially convenient when it comes to highway landscape maintenance. Although we socalled environmentalists are discouraged at times, we have to agree that to try and maintain all of our highway plantings in a lush, tropical garden atmosphere would be uneconomical. At the same time, we cannot agree that all of the landscaped areas should be allowed to survive without any maintenance other than occasional watering.

Realizing that we had to strike some compromise with fiscal capabilities, the State Highways Division developed criteria for and classification of all State highways; landscaping on State highways is therefore now divided into three classes:

1. Class A: Neat, well-kept areas with park-like appearance. Manicured lawn areas approaching promenade standards with regular mowing and clean edging. Trees, shrubs, and vines pruned for aesthetics with pedestrian and motorist safety in mind. Every effort shall be made to keep areas weed free.

   To achieve this high level of development, an automatic sprinkler system and at least 6 inches of good, screened topsoil is mandatory in its construction. A complete fertilizer shall be applied three times a year at an annual rate of at least 700 pounds per acre.

2. Class B: Moderate maintenance areas where functional planting predominates. Periodic mowing performed as height of ground cover is not critical. Emphasis on trimming and mowing to areas of encroachment to traffic lanes or hindrance to sight distance. Plantings primarily to provide center headlight screen; roadside screens to lessen noise, dust and headlight glare; and screens for the benefit of adjacent development.

   Construction specifications should include the removal of all stones and debris for safety in maintenance. Trees pruned primarily for delineation of route, structures, and curves.

3. Class C: Low maintenance areas where soil erosion and flood control are the major concerns. Plantings for wind and water erosion control blend into the natural landscape. Mowing and trimming done only to control encroachment to traffic lanes and maintain good sight distance. Trees pruned for safety reason.

For the present, our Class A designation has been on highways within the City proper and the major interchanges of the Interstate system. As funds and manpower become more available we are hoping to expand into other areas of population densities.

Based on the adoption of these standards, we were able to at least justify the inclusion of funds in our budget for the purchase of needed fertilizer, which is what you probably wished to hear. For example, during iscal year 1971-1972, we used 35 tons of fertilizer for our highways on Oahu. In the period 1972-1973, this amount rose to 60 tons. We are also emphasizing the manpower needed to apply this fertilizer to the areas, although the present freeze on State hiring has slowed us down temporarily. Furthermore, during the past year, we have included in our construction contracts a requirement for 1 year's establishment period, during which the landscape contractor is required to fertilize all planted areas at a rate of 300 pounds per acre at least three times during the period.

The major problem of finances in highway fertilizing seems to be easing, but other problems will soon emerge. Diversity of soils will challenge you all in providing organic fractions and soil amendments, correcting minor element deficiencies, and adapting to the variety of plant materials that will go into our highway beautification efforts.

More and more, your field representatives will have to be competent horticulturists who will be able to not only advise us in the need of proper nutrients for our plantings but also to advise your production managers to produce materials that will effectively result in aesthetically pleasing highways. You have done quite well in the past, coming up with pelletized fertilizer, slow-release fertilizer, water-soluble fertilizer, and even fertilizer with minor elements added. I commend you for this effort and urge you to continue your production to meet the peculiar requirements of the consumer.

Although the recent increases in costs of fertilizers may be a deterrent to the industry, I can see an increased need for proper fertilizers in the future. The persistent emphasis on maintaining present levels of air quality is going to result in more plantings on our highways. The paving of 1 acre of sugarcane or any other crop will eliminate oxygen production by at least 20 tons per year. We can compensate for this lowering of air quality through increased production within the remaining planted areas. This can only be done by growing what is left in a vigorous and healthy condition. You know as well as I do that this means proper and adequate fertilization. It will mean a complete reevaluation of our plant materials. We shall have to look at plants not only as things of beauty but also as functional elements in man's survival. We may have to determine the carbon dioxide absorption and molecular-oxygen-producing capacities of different plants as well as the shape and color of leaves and flowers. All of these factors will have to be considered by landscape architects if we wish to prepare an adequate Environmental Impact Statement. Until man can improve his technology to economically do what plants are doing through photosynthesis, I see no alternative but to improve our horticultural practices substantially.

The challenge is there for us to meet. Together we can produce a State highway system which will not only be safe but also pleasing, beautiful, and functional.

FERTILIZER MANAGEMENT FOR THE HOMEOWNER

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Fertilizers are essential for good plant growth in Hawaii. Fertilizer recommendations are generally given in pounds per acre; however, few homeowners have plant areas of this size, and they need recommendations based upon these smaller areas. The home gardener also needs information about analyses, methods of application, and other soil management practices. The purpose of this presentation is to provide such helpful information for the homeowner.

Fertilizers are applied to the soil to supply the nutrient needs of the plants grown on that soil. Soils differ in their capacity to retain and/or supply nutrients to plants, and different kinds of plants have different requirements for nutrients. To determine the amount and kind of fertilizer required for a specific soil-plant combination, a soil test sould be made and the recommendations followed for best results.

There are many different kinds of fertilizer available to the homeowner. Some are solids and some liquids, some chemical and some organic, some high analysis and some low analysis, and some have one brand and some another. Generally, the brand name makes little difference in the fertilizer if the same ingredients are used and if they are combined in the same manner. These fertilizers are made up of carriers--materials that supply the plant nutrients. Some carriers contain only one nutrient--for example, urea--and some may contain more than one--for example, ammonium sulfate. Fertilizers that supply the needs of the particular plant on the specific soil should be used. Fertilizer packages contain a statement that indicates the amount of plant nutrients in the material. A set of three figures, such as 10-30-10, 16-16-16, or other number group, is generally found on mixed fertilizers: the first figure indicates the percentage of nitrogen (N), the second the percentage of available phosphoric acid (P_2O_5), and the third the percentage of water-soluble potash (K_2O) present. At present, the American Society of Agronomy suggests that the percentages of P_2O_5 and K_2O be stated as the elemental form the same way as is done for N. When this is done, the phosphorus (P) will be 0.44 P_2O_5, and the potassium (K) will be 0.83 K_2O. The actual amount of plant nutrient (or its form) will not be changed; only the method by which the amount is stated on the package will be changed. It is difficult to state which analysis of fertilizer would be best for different crops as this is best determined by soil testing. However, for general purposes, the 1-3-1 ratios, such as 10-30-10 or 13-32-10, would be best for vegetable crops, fruit trees (except banana and papaya), and most shrubs and trees. The 1-1-1 ratios, such as 16-16-16 or 20-20-20, would be best for papaya and annual flowers. A 2-1-4 ratio, such as 10-5-20, would be best for banana. A 2-1-1 or 4-1-1 ratio, such as 16-8-8 or 16-4-4, would be best on lawns or other turf, although when lawns are first established in Hawaii, the use of 1-3-1 or 1-2-2 ratios prove best due to the ability of most Hawaiian soils to fix large quantities of phosphorus.

The form of fertilizer makes little difference as long as the solubility and the amount of plant nutrients are the same. Dry fertilizers and liquid fertilizers and all soluble and liquid fertilizers have the same effect on plant growth if they are applied to the plant at the same rate and by the same method. There is a difference, however, in the response of plants to soluble vs. slowly soluble materials and to use of natural organics due to the slower rate of release from the slowly soluble and organic products. This is a desirable feature for some plants, such as lawns, ornamental shrubs, and trees, on soils where leaching is a problem or where a slow rate of growth is desired. On short-season plants, such as vegetables, the more soluble fertilizers are needed. For fruit trees and flowering plants, the more soluble fertilizers are also best as these plants generally put on new growth three times a year and should be fertilized just before each flush of new growth.

There is a controversy regarding the value of organic or natural and chemical fertilizers. The impression is given that chemical fertilizers poison the ground, kill beneficial insects, and lower the quality of the plants whereas organic fertilizers produce bigger, better, and healthier plants. The home gardener should realize that the plant requires each nutrient in a form that it can take up and utilize in its growth processes; it cannot distinguish between those forms that originate from "chemical" sources or "organic" sources. It generally can obtain what is needed from "chemical" sources as they are usually more soluble and can supply plant needs more quickly; on the other hand, the "organic" sources need to undergo decomposition before plants can obtain the nutrients. Organic sources also add humus to the soil, which improves the water-holding capacity, nutrient-holding capacity, and tilth of the soil. The best management program would use principles of both organic and chemical farming for most efficient plant growth. The organic materials are generally lower in plant nutrient content as compared to chemical sources. They are more expensive than the chemical sources because most are used for livestock feed and the total supply is less. Many organic wastes may be used either to make composts or for direct mixing with the soil. Most composts are equivalent to cow manure after decomposition and when ready to add to the soil. The use of manures, when properly supplemented with phosphorus and potassium, are excellent sources of plant nutrients.

Fertilizers may be applied in different ways. The best method depends upon the plant, the size of area, the type of material, and the desires of the grower. "Broadcast" application means spreading the fertilizer uniformly over the area and mixing it with the soil to the rooting depth of the plant. If the plants are already established and the fertilizer remains on the surface, this is known as "top-dressing" the plant. This method is used for lawns and other areas where the entire soil surface is occupied or covered by the plants. It may be used also for small home vegetable garden plots or where large amounts of fertilizer are to be applied. "Band placement" places the fertilizer in either continuous or discontinuous bands alongside the row or in the row. For large-seeded plants, such as beans and peas, the fertilizer is placed in bands 2 inches below the seed level and 2 to 3 inches to the side. For small-seeded plants, such as carrots and lettuce, place the fertilizer in a band 1 to 1 1/2 inches below the seed level. For sidedressing, when applying fertilizer after the plants are established in the row, place the fertilizer in a band 2 to 3 inches to the side of the row in a shallow trench and cover with soil. The fertilizer may be placed on top of the soil and not covered, but results are not as rapid as when buried in the shallow trench. "Hill placement" is similar to band placement except the fertilizer is placed in a circle around the hill in which the plant is placed. For trees and shrubs, the fertilizer should be placed around the tree within the leaf drip of the tree. It should not be closer than 3 to 4 inches from the base of the tree to reduce the danger of burning. Placing the fertilizer in holes that vary in depth from 6 to 24 inches and at random within the leaf drip area is best; however, the fertilizer may be spread over the surface of the ground with excellent results. Fertilizer may be sprayed on the leaves of plants with good results. However, dilute solutions are required, and the use of a "sticker-spreader" to break up the surface tension of water and cause a uniform covering of the plants' foliage gives better results. Sprays are generally used for the micronutrients as small amounts of these nutrients are required, and one to three applications a year will meet the needs of most plants.

The time of application is important. Before establishing lawns or turf, all the materials should be added and mixed with the soil before planting. This is especially true of the phosphorus as it will not move down into the soil from the surface. Then the fertilizer should be applied as often as needed to maintain the desired color of the grass. For trees and shrubs, the fertilizer should be applied just before or as each flush of growth begins--generally three times a year, in February, June, and October. Sprays can be applied as the plant shows a need for the nutrient. For vegetables, one-half of the fertilizer should be applied at the time of planting and one-half when the plants are about 4 weeks old. For lettuce and leafy vegetables, an application of nitrogen 2 weeks after planting will produce good results. For sweet corn, an application of nitrogen 6 to 8 weeks after planting will increase the yield and size of ears. For tomatoes and other vine crops, an application of nitrogen after the first fruit set and then every 3 or 4 weeks until after harvest is completed is best. For potted plants, an application of fertilizer every 2 to 3 months produces good results. On bananas, apply fertilizer every three months, and on papayas, every month.

The amount of fertilizer to apply depends upon the nutrient requirement of the plant. Bananas should receive 1 to 2 pounds of fertilizer per month for the first 6 months and then 3 to 4 pounds per month. Papaya should receive 1/4 pound per hill the first 3 months, 1/2 pound per hill the next 3 months, 1 pound per hill the next 3 months, and then 2 to 3 pounds per hill as long as the harvest continues. Lawns should receive 2 to 3 pounds per 1000 square feed of nitrogen at each application. If a 21 percent N carrier is used, 10 to 15 pounds per 1000 square feet per application is required; if a 10 percent N carrier, then 20 to 30 pounds per 1000 square feet. Generally, it is best to use a complete fertilizer (one containing N-P-K) in late spring and late fall and a straight N carrier the rest of the time. For vegetable gardens, apply 2 to 2 1/2 pounds fertilizer per 1000 square feet at planting and again when plants are about 4 weeks old. When sidedressing with nitrogen, add 1 pound per 100 square feet of ammonium sulfate or its equivalent for all vegetables. When fertilizing fruit trees, apply 1 pound for each 1 inch in diameter of the tree three times a year. For shrubs and flowers, apply 1 1/2 to 2 pounds per 100 square feet of area each time. If using manure, compost, or other organic material, apply 46 to 50 pounds per 100 square feet before establishing the plants. When using chicken manure, apply one-half of this amount and wait at least 10 days before planting. When transplanting, use a starter solution made by mixing 2 ounces of regular fertilizer or 2 teaspoons of liquid or all soluble fertilizer per gallon of water at the rate of 1 pint per plant to reduce the shock of transplanting and produce larger, healthier plants. Complete fertilizers high in phosphorus should be used to make starter solutions. For potted plants, the use of 5 to 10 pellets of pelleted fertilizer at each application will be satisfactory or the use of continuous feed by using dilute solutions made by adding 1 teaspoonful of an all-soluble or liquid fertilizer to a gallon of water and applying each time the plant requires water will give good results. An occasional flushing with pure water would reduce the danger of soluble salt buildup in the containers.

The soil should be moist but not wet when fertilizers are applied. Watering the plants after application will reduce the danger of "burning" plants when chemical fertilizers are used; however, when organic materials are applied, heavy watering may wash away some of the lightweight organic materials.

The effective use of applied fertilizers depends, in part, upon the soil reaction or pH of the soil. The optimum pH depends upon the type of plants grown.

Most plants around the home grow best where the pH is between 6.0 and 7.0; however, some plants, such as azeleas, grow best when soil pH is between 4.5 and 5.0. The soil should be tested and the pH adjusted to the proper level before applying fertilizers and planting. Do not try to grow plants with widely differing pH levels in the same area.

Fertilizers will not solve all the problems of growing plants. The soil must be loose enough for adequate air and moisture to be present; adequate water must be applied as needed; disease and insects must be controlled; and competition from weeds must be eliminated. If all these factors are properly in balance, fertilizers will produce beautifully healthy plants that will be a joy to behold and a source of satisfaction to the grower.

SALINITY MANAGEMENT IN HAWAIIAN GREENHOUSES

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Conditions that contribute to the development of soil salinity in greenhouses include the application--and especially the excessive application--of fertilizer salts, the presence of salts in irrigation water, and insufficient soil leaching. While nearly all fertilizer applied in excess of plant needs increases soil salinity, even some of that required by the crop leaves a salt residue. For example, because plants absorb relatively little chloride and sulfate relative to nitrogen and potassium, applications of fertilizer salts, such as ammonium sulfate and potassium chloride, leave nearly equivalent amounts of salt in the soil after plant utilization of the nitrogen and potassium, the cations pairing with the sulfate and chloride being calcium and magnesium from the soil absorptive material. Phosphorus fertilizers do not increase soil salinity, however, because the soil and crop absorb essentially all phosphorus applied. The salinity of irrigation waters varies greatly, with some usable waters containing as much as 1 or 2 tons salt per acre-foot. Little of the salt in irrigation water is absorbed by plants. Causes of insufficient leaching of excess salts from greenhouse soils include the absence of rainfall on the soil, insufficient application of irrigation water, only partial wetting of the soil surface as with drip or furrow irrigation, and sometimes impeded drainage.

Plants respond adversely to soil salinity in two main ways. The first, which occurs with the herbaceous plants (field, forage, and vegetable crops), is a general stunting of growth associated with an excessive osmotic potential of the soil water. Growth may be reduced as much as one-fourth or one-third with no visual symptoms of injury. The second, which occurs with woody plants, is by marginal burning of leaves followed by necrosis of both leaves and twigs owing to excessive accumulation of chloride and sometimes sodium.

The key tool for managing soil salinity is the soil salinity test. The object of the test is to obtain a measure of the osmotic potential of the soil solution over the field water-content range. Because the osmotic potential of a mixed salt solution is highly related to its electrical conductivity, and the water content of a saturated soil paste is usually about two and four times the field capacity and wilting water contents, respectively, the electrical conductivity of a saturation water-extract (EC_e)-expressed in millimhos per centimeter (mmho/cm) is commonly used as a measure of soil salinity. In at least some and probably most highly aggregated, Hawaiian soils, the usual relation between the saturated paste and field range of water contents does not occur. The paste water content is not much greater than the field capacity content and is only about twice the wilting content. This means that most published EC_e values associated with reductions in crop yields should be divided by about two.

The accompanying figures show relations between the relative yield of the 'Tropic' variety of tomato and the electrical conductivity of (1) the soil water at the field capacity and (2) the saturated paste water contents of volcanic ash soil at Kainaliu, Hawaii. Also shown are similar data by the U.S. Salinity Laboratory for soils in general and for varieties of tomato grown in western United States. The relations at the field capacity water content show that the 'Tropic' variety is only half as salt tolerant as the weatern U.S. varieties, whereas the relations at the paste water content erroneously indicate that the varieties have similar tolerance. The water contents of the Kainaliu volcanic ash soil at wilting, field capacity, and saturation are 32, 60, and 70 percent, respectively. For another volcanic ash soil studied at Volcano, Hawaii, the field capacity water content (98 percent) actually exceeds the saturation paste content (90 percent), apparently owing to disruption of soil aggregates during preparation of the paste. More information is needed on the relation between the field capacity and saturated paste water contents of Hawaiian soils.

Most Hawaiian greenhouse soils have high water-holding capacities and, therefore, they tend to become saline relatively slowly. When they do become saline, however, relatively large amounts of irrigation water are required for leaching. It is prudent, therefore, to test the greenhouse soil periodically for salinity and apply extra water for leaching when the test indicates incipient yield reduction. An appropriate time to leach is between crops. Leaching is most efficient when water is applied by sprinkling. Sprinkling wets the entire soil surface and, unless ponding of water occurs, causes the applied water to move through the soil micropores where most of the salt is held. Leaching by ponding water is relatively inefficient on highly aggregated, Hawaiian soils because the applied water moves rapidly through the many macropores leaving the salt in the micropores behind. As a general rule, when soil is leached by sprinkling, the passage of a depth of water equivalent to the volume of pore space in the depth will remove about 80 percent of the salt present. With ponding, this volume may remove less than half of the salt present.

Because of the widespread use of drip irrigation in greenhouses, the relation of this method of irrigation to salinity control deserves special comment. Since there is frequent application of water under drip irrigation, the water content of the extended V- or cone-shaped wetted soil volume containing the plant roots remains relatively high, thereby minimizing salt concentrations. This permits use of appreciably more saline irrigation water and otherwise more saline conditions without yield reductions, but salt does accumulate between the wetted volumes. Although, depending on the amount of water applied, some deep leaching may occur at the bottom of the V or cone, it is usually necessary to leach the entire soil periodically, preferably by sprinkling. Here again, soil sampling and salinity testing is the best guide for the need to leach.

If for some reason, such as use of a rather saline irrigation water, it is not feasible to maintain low salinity levels in the greenhouse soil, there are several management practices for minimizing the adverse effects of salinity on plant growth. One practice is to grow a salt-tolerant crop or possibly a more salt-tolerant variety of a particular crop. The salt tolerance of cultivated species varies more than ten-fold, and, with some crops, varieties differ significantly in tolerance. Frequently, varieties selected or bred in arid areas are more salt tolerant than those developed in humid areas. Another practice for minimizing salinity effects is to maintain a high soil-water content so as to keep the salt concentration of the soil solution as low as possible. As already mentioned, this is achieved by drip irrigation. Still other practices depend upon the fact that the salt tolerance of most crops is least during the germination and seedling stages of growth. The salt concentration of the soil water in the vicinity of the germinating seed or seedling may be kept low by frequent sprinkling or furrow irrigation, by planting on the slopes or shoulders of beds where, under furrow irrigation, salts do not accumulate, and by applying fertilizer where it will not be contacted by roots until the crop is past the seedling stage.

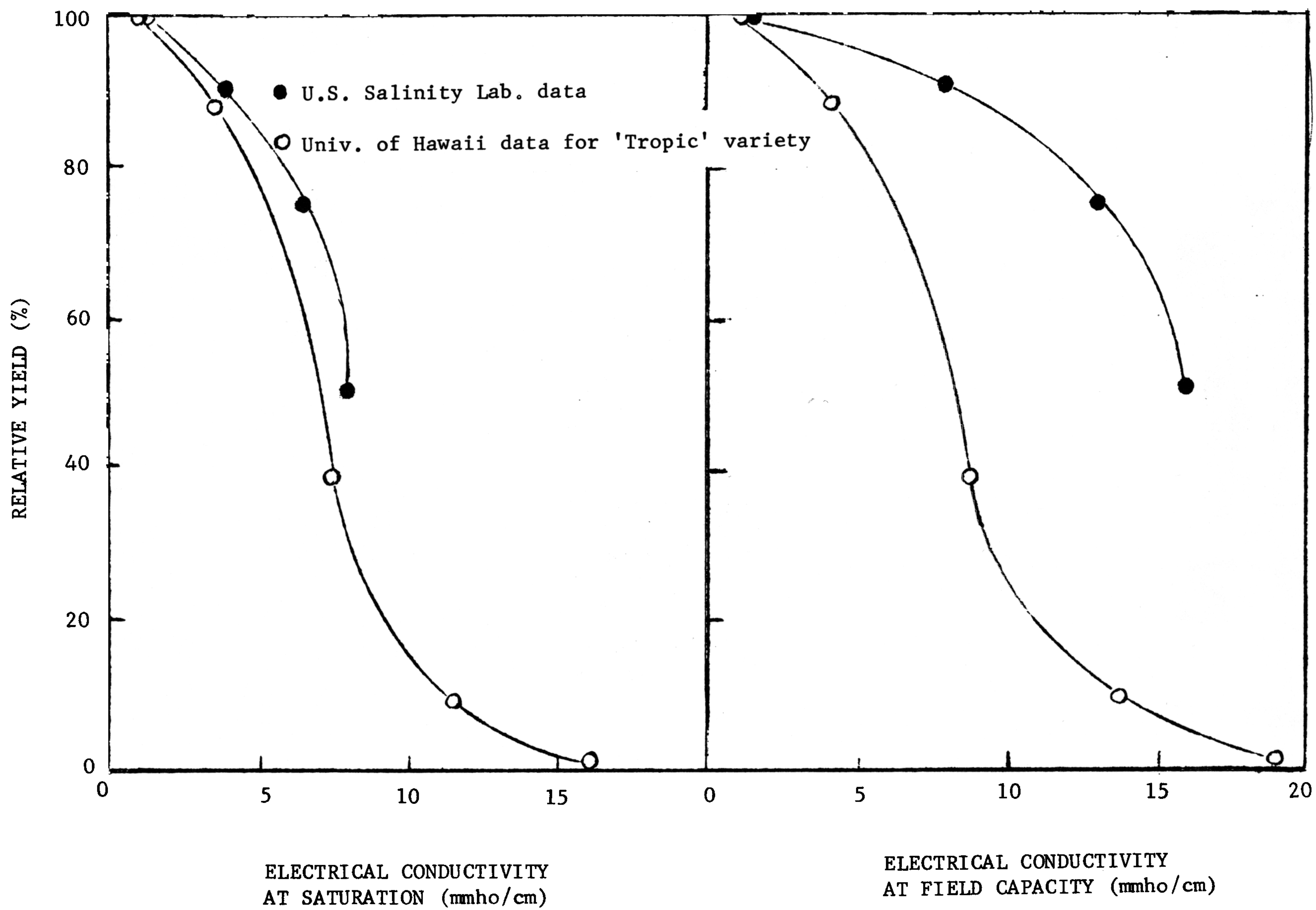

FIGURE 1. Relation between the relative yield of tomato and the electrical conductivity of the soil water at saturation and of field capacity.